SOIL SURVEY

Sherburne County Minnesota

Issued February 1968

UNITED STATES DEPARTMENT OF AGRICULTURE
Soil Conservation Service
In cooperation with
MINNESOTA AGRICULTURAL EXPERIMENT STATION

Major fieldwork for this soil survey was done in the period 1950–60. Soil names and descriptions were approved in 1965. Unless otherwise indicated, statements in the publication refer to conditions in the county in 1960. This survey was made cooperatively by the Soil Conservation Service and the Minnesota Agricultural Experiment Station. It is part of the technical assistance furnished to the Sherburne Soil and Water Conservation District.

HOW TO USE THIS SOIL SURVEY

THIS SOIL SURVEY contains information that can be applied in managing farms and woodlands; in selecting sites for roads, ponds, buildings, or other structures; and in appraising the value of tracts of land for agriculture, industry, or recreation.

Locating Soils

All of the soils of Sherburne County are shown on the detailed map at the back of this publication. This map consists of many sheets that are made from aerial photographs. Each sheet is numbered to correspond with numbers shown on the Index to Map Sheets.

On each sheet of the detailed map, soil areas are outlined and are identified by symbol. All areas marked with the same symbol are the same kind of soil. The soil symbol is inside the area if there is enough room; otherwise, it is outside and a pointer shows where the symbol belongs.

Finding and Using Information

The "Guide to Mapping Units" can be used to find information in this publication. This guide lists all of the soils of the county in alphabetic order by map symbol. It shows the page where each kind of soil is described, and also the page for the capability unit and the woodland group in which the soil has been placed.

Individual colored maps showing the relative suitability or limitation of soils for many specific purposes can be developed by using the soil map and information in the text. Interpretations not included in the text can be developed by grouping the soils according to their suitability or limitation for a particular use. Translucent material can be used as an overlay over the soil map and colored to show soils that have the same limitation or suitability. For example, soils that have a slight limitation for a given use can be colored green, those with a moderate limitation can be colored yellow, and those with a severe limitation can be colored red.

Farmers and those who work with farmers can learn about use and management of the soils from the descriptions of the soils and from the discussions of the capability groups.

Foresters and others can refer to the section "Woodland," where the soils of the county are grouped according to their suitability for trees.

Game managers, sportsmen, and others concerned with wildlife will find information about soils and wildlife in the section "Wildlife and Recreation."

Engineers and builders will find under "Engineering Applications" tables that describe soil properties that affect engineering and show the relative suitability of the soils for specified engineering purposes.

Scientists and others can read about how the soils were formed and how they are classified in the section "Formation and Classification of the Soils."

Students, teachers, and others will find information about soils and their management in various parts of the text, depending on their particular interest.

Newcomers in Sherburne County may be especially interested in the section "General Soil Map," where broad patterns of soils are described. They may also be interested in the section "Additional Facts About the County."

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NOTICE TO LIBRARIANS

Series year and series number are no longer shown on soil surveys. See explanation on the next page.

Issued February 1968

EXPLANATION

Series Year and Series Number

Series year and number were dropped from all soil surveys sent to the printer after December 31, 1965. Many surveys, however, were then at such advanced stage of printing that it was not feasible to remove series year and number. Consequently, the last issues bearing series year and number will be as follows:

Series 1957, No. 23, Las Vegas and Eldorado Valleys Area, Nev.
Series 1958, No. 34, Grand Traverse County, Mich.
Series 1959, No. 42, Judith Basin Area, Mont.
Series 1960, No. 31, Elbert County, Colo. (Eastern Part)
Series 1961, No. 42, Camden County, N.J.
Series 1962, No. 13, Chicot County, Ark.
Series 1963, No. 1, Tippah County, Miss.

Series numbers will be consecutive in each series year, up to and including the numbers shown in the foregoing list. The soil survey for Tippah County, Miss., will be the last to have a series year and series number.

SOIL SURVEY OF SHERBURNE COUNTY, MINNESOTA

BY M. F. GRIMES, SOIL CONSERVATION SERVICE

FIELD SURVEY BY M. F. GRIMES, M. G. ZIEBELL, C. K. SUTTON, L. M. CHAMBERLAIN, AND E. MEIR, SOIL CONSERVATION SERVICE

UNITED STATES DEPARTMENT OF AGRICULTURE, SOIL CONSERVATION SERVICE, IN COOPERATION WITH THE MINNESOTA AGRICULTURAL EXPERIMENT STATION

SHERBURNE COUNTY is in the central part of Minnesota (fig. 1). It has a total land area of

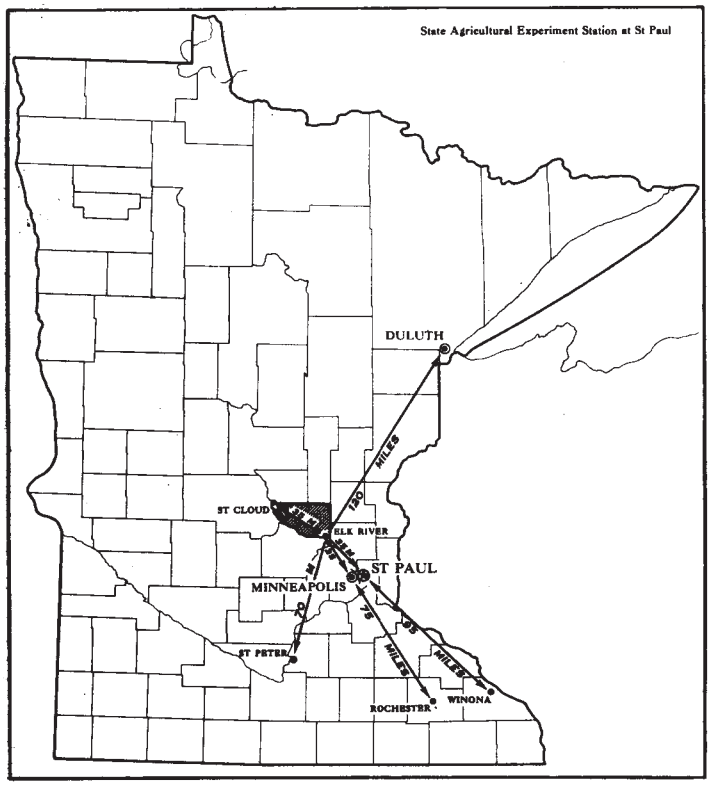

Figure 1.—**Location of Sherburne County in Minnesota.**

280,320 acres. The village of Elk River, the county seat, is in the southeastern corner of the county. It is 35 miles northwest of St. Paul and 35 miles southeast of St. Cloud. Other important towns and settlements in the county are Big Lake, Becker, Clear Lake, Zimmerman, Santiago, and part of the city of St. Cloud.

How This Soil Survey Was Made

Soil scientists made this survey to learn what kinds of soils are in Sherburne County, where they are located, and how they can be used. They went into the county knowing they likely would find many soils they had already seen, and perhaps some they had not. As they traveled over the county, they observed steepness, length, and shape of slopes; size and speed of streams; kinds of native plants or crops; kinds of rock; and many facts about the soils. They dug many holes to expose soil profiles. A profile is the sequence of natural layers, or horizons, in a soil; it extends from the surface down into the parent material that has not been changed much by leaching or by roots.

The soil scientists made comparisons among the profiles they studied, and they compared these profiles with those in counties nearby and in places more distant. They classified and named the soils according to nationwide, uniform procedures. To use this survey efficiently, it is necessary to know the kinds of groupings most used in a local soil classification.

Soils that have profiles almost alike make up a soil series. Except for different texture in the surface layer, the major horizons of all the soils of one series are similar in thickness, arrangement, and other important characteristics. Each soil series is named for a town or other geographic feature near the place where a soil of the series was first observed and mapped. Hubbard and Milaca, for example, are the names of two soil series. All the soils in the United States having the same series name are essentially alike in those characteristics that affect their behavior in the natural, undisturbed landscape. Soils of one series can differ somewhat in texture of the surface soil and in slope, stoniness, or some other characteristic that affects use of the soils by man.

Many soil series contain soils that differ in the texture of their surface layer. According to such differences in texture, separations called soil types are made. Within a series, all the soils having a surface layer of the same texture belong to one soil type. Hubbard sandy loam and Hubbard loamy sand are two soil types in the Hubbard series. The difference in the texture of their surface layers is apparent from their names.

Some soil types vary so much in slope, degree of erosion, number and size of stones, or some other feature affecting their use, that practical suggestions about their management could not be made if they were shown on the soil map as one unit. Such soil types are divided into soil phases. The name of a soil phase indicates a

feature that affects management. For example, Milaca fine sandy loam, 0 to 2 percent slopes, is one of several phases of Milaca fine sandy loam, a soil type that has a slope range of 0 to 25 percent.

After a guide for classifying and naming the soils had been worked out, the soil scientists drew the boundaries of the individual soils on aerial photographs. These photographs show woodlands, buildings, field borders, trees, and other details that help in drawing boundaries accurately. The soil map in the back of this survey was prepared from the aerial photographs.

The areas shown on a soil map are called mapping units. On most maps detailed enough to be useful in planning management of farms and fields, a mapping unit is nearly equivalent to a soil type or a phase of a soil type. It is not exactly equivalent, because it is not practical to show on such a map all the small, scattered bits of soil of some other kind that have been seen within an area that is dominantly of a recognized soil type or soil phase.

In preparing some detailed maps, the soil scientists have a problem of delineating areas where different kinds of soils are so intricately mixed or occur in such small individual tracts that it is not practical to show them separately on the map. They show this mixture of soils as one mapping unit and call it a soil complex. Ordinarily, a soil complex is named for the major kinds of soil in it, for example, Emmert-Hayden complex.

Another kind of mapping unit is the undifferentiated group, which consists of two or more soils that may occur together without regularity in pattern or relative proportion. The individual tracts of the component soils could be shown separately on the map, but the differences between the soils are so slight that the separation is not important for the objectives of the soil survey. An example is Emmert and Chetek soils.

In most areas surveyed there are tracts in which the soil material is so rocky, so shallow, or so frequently worked by wind and water that it scarcely can be called soil. These tracts are shown on a soil map like other mapping units, but they are given descriptive names, such as Beach sand or Alluvial land, and are called land types rather than soils.

While a soil survey is in progress, samples of soils are taken, as needed, for laboratory measurements and for engineering tests. Laboratory data from the same kinds of soils in other places are assembled. Data on yields of crops under defined practices are assembled from farm records and from field or plot experiments on the same kinds of soils. Yields under defined management are estimated for all the soils.

But only part of a soil survey is done when the soils have been named, described, and delineated on the map, and the laboratory data and yield data have been assembled. The mass of detailed information then needs to be organized in such a way that it is readily useful to different groups of readers, among them farmers, managers of woodland, engineers, and homeowners. Grouping soils that are similar in suitability for each specified use is the method of organization commonly used in soil surveys. The soil scientists set up trial groups, based on the yield and practice tables and other data. They test these groups by further study and by consultation with farmers, agronomists, engineers, and others; then they adjust the groups according to the results of their studies and consultation. Thus, the groups that are finally evolved reflect up-to-date knowledge of the soils and their behavior under present methods of use and management.

General Soil Map

The general soil map at the back of this publication shows, in color, the soil associations in Sherburne County. A soil association is a landscape that has a distinctive proportional pattern of soils. It normally consists of one or more major soils and at least one minor soil, and it is named for the major soils. The soils in one association may occur in another, but in a different pattern.

A map showing soil associations is useful to people who want a general idea of the soils in a county, who want to compare different parts of a county, or who want to know the location of large tracts that are suitable for a certain kind of farming or other land use. Such a map is not suitable for planning the management of a farm or field, because the soils in any one association ordinarily differ in slope, depth, stoniness, drainage, and other characteristics that affect management.

The five associations in Sherburne County are described in the paragraphs that follow.

1. Hubbard-Estherville-Salida association

Nearly level to gently rolling, sandy soils over deeply leached sand or calcareous gravel

This association occurs as a sand plain 1 mile to 10 miles wide along the Mississippi River. It extends from St. Cloud, in the northwestern corner of the county, through Elk River, in the southeastern part, to the eastern boundary. Most of the association is nearly level to gently rolling, but moderate slopes surround the depressions and lakes, and steep terrace breaks occur along the Mississippi River. This association occupies about 34 percent of the county.

This association consists predominantly of Hubbard, Estherville, and Salida soils (fig. 2) but includes small acreages of Wadena soils and Isanti soils. Hubbard soils are somewhat excessively drained or excessively drained, deeply leached outwash sands. Their surface layer is dark colored and is either sandy loam or loamy sand. Estherville soils are somewhat excessively drained, dark-colored sandy loams that are shallow over calcareous gravel. Salida soils are excessively drained, dark-colored loamy sands that also are shallow over calcareous gravel.

The dominant soils in this association are suited to general farming, but all are droughty, particularly the coarse-textured Salida soils which are shallow over sand and gravel, and all are highly susceptible to wind erosion, especially in spring. The sandblasting effect of the blowing sand damages crops. Corn, soybeans, alfalfa, and rye are grown. Yields are low. Small areas of Hubbard and Estherville soils are uncleared and support scrub oak. These areas are most common along the Mississippi River. They are used as pasture.

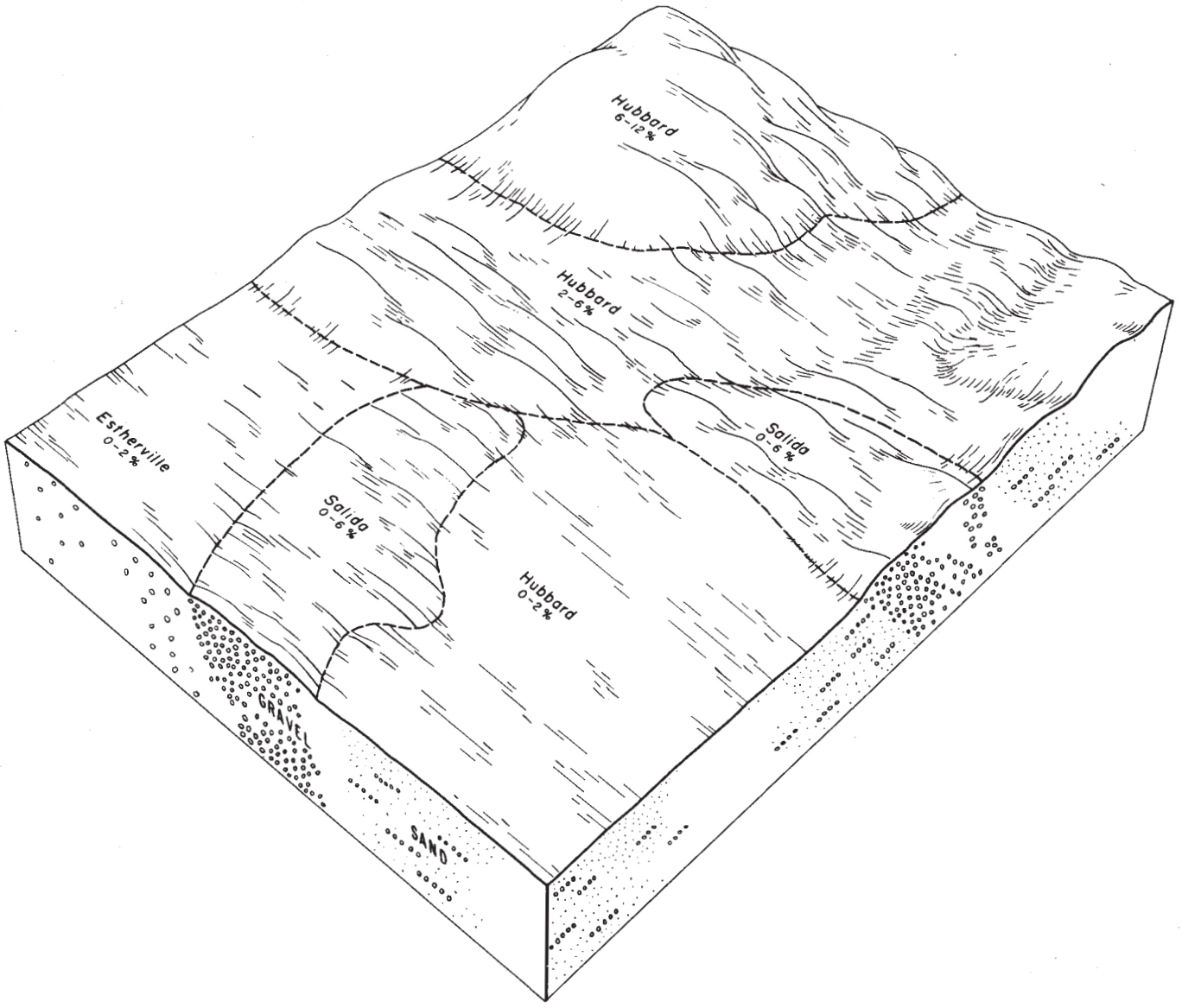

Figure 2.—**Representative pattern of major soils in association 1.**

2. *Zimmerman-Lino-Isanti-peat association*

Nearly level to undulating, acid, windblown, sandy soils

This association occurs as one large area that occupies the northeastern and central parts of the county. Most of it is nearly level to undulating, but parts are rolling and hilly. This association makes up about 49 percent of the county.

This association consists predominantly of Zimmerman, Lino, and Isanti soils and many small, scattered peat bogs (fig. 3). Zimmerman soils are excessively drained and droughty, Lino soils are somewhat poorly drained, and Isanti soils are depressional and are very poorly drained. All are fine sands.

The soils in this association are suited to general farming. Soybeans, corn, alfalfa, and rye are grown. Yields are low, because of either wetness or droughtiness and the cutting action of windblown sand. Wind erosion has been so severe in some areas of Zimmerman soils that there are blown-out spots, mainly in areas near the Sand Dunes State Forest. Some areas of Zimmerman soils are uncleared and support scrub oak. Many fields that were formerly cultivated are now Christmas-tree plantations. A large number of farmers on this association derive part of their income from off-the-farm employment. Many are absentee owners.

3. *Milaca-Mora-Ronneby association*

Nearly level to undulating soils over slightly acid, red glacial till

This association occurs as three small areas in the northern part of the county. The largest area is near Santiago. Most of this association is nearly level to undulating, but a small acreage is rolling, and there are a

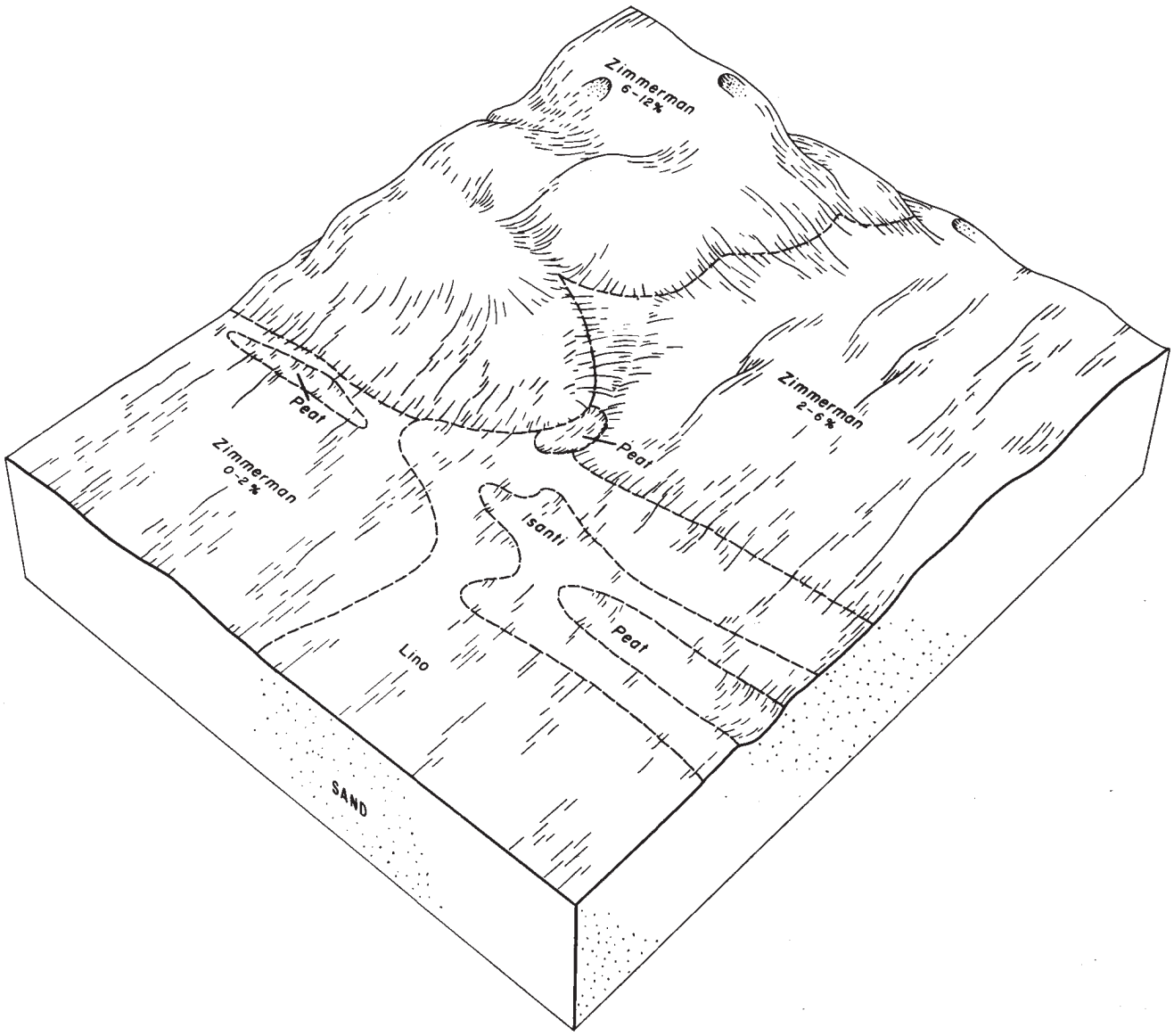

Figure 3.—**Representative pattern of major soils in association 2.**

few depressions. This association makes up only 3 percent of the county.

This association consists predominantly of Milaca, Mora, and Ronneby soils (fig. 4) but includes areas of Pomroy and Adolph soils and areas of undifferentiated soils in depressions. Milaca soils are well-drained fine sandy loams that have a subsoil of slightly acid sandy clay loam. Mora soils are moderately well drained loams, and Ronneby soils are somewhat poorly drained loams.

The dominant soils in this association are stony and cobbly. Ronneby soils and the minor soils in the association are wet. Dairy farming is the principal type of farming. Corn, oats, hay, and pasture grasses are grown. Some areas are uncleared and support fair stands of mixed hardwoods. Most woodlots and the undrained depressions are used as pasture.

4. Hayden-Braham-Emmert association

Undulating to steep soils over limy, gray glacial till mixed with red till or gravel or capped with fine sand

This association occurs as small, scattered areas throughout the county. About 80 percent of it is undulating to steep, and the rest is flat or slightly depressional. The elevation of each area is higher than that of the surrounding sand plain. This association occupies about 7 percent of the county.

This association consists predominantly of Hayden, Braham, and Emmert soils (fig. 5) but includes small areas of Isanti soils and small peat bogs. Hayden soils are well-drained, grayish-brown fine sandy loams that have a subsoil of limy clay loam. Braham soils are well-drained loamy fine sands. They are 2 to 4 feet thick over till or medium-textured lacustrine deposits and are

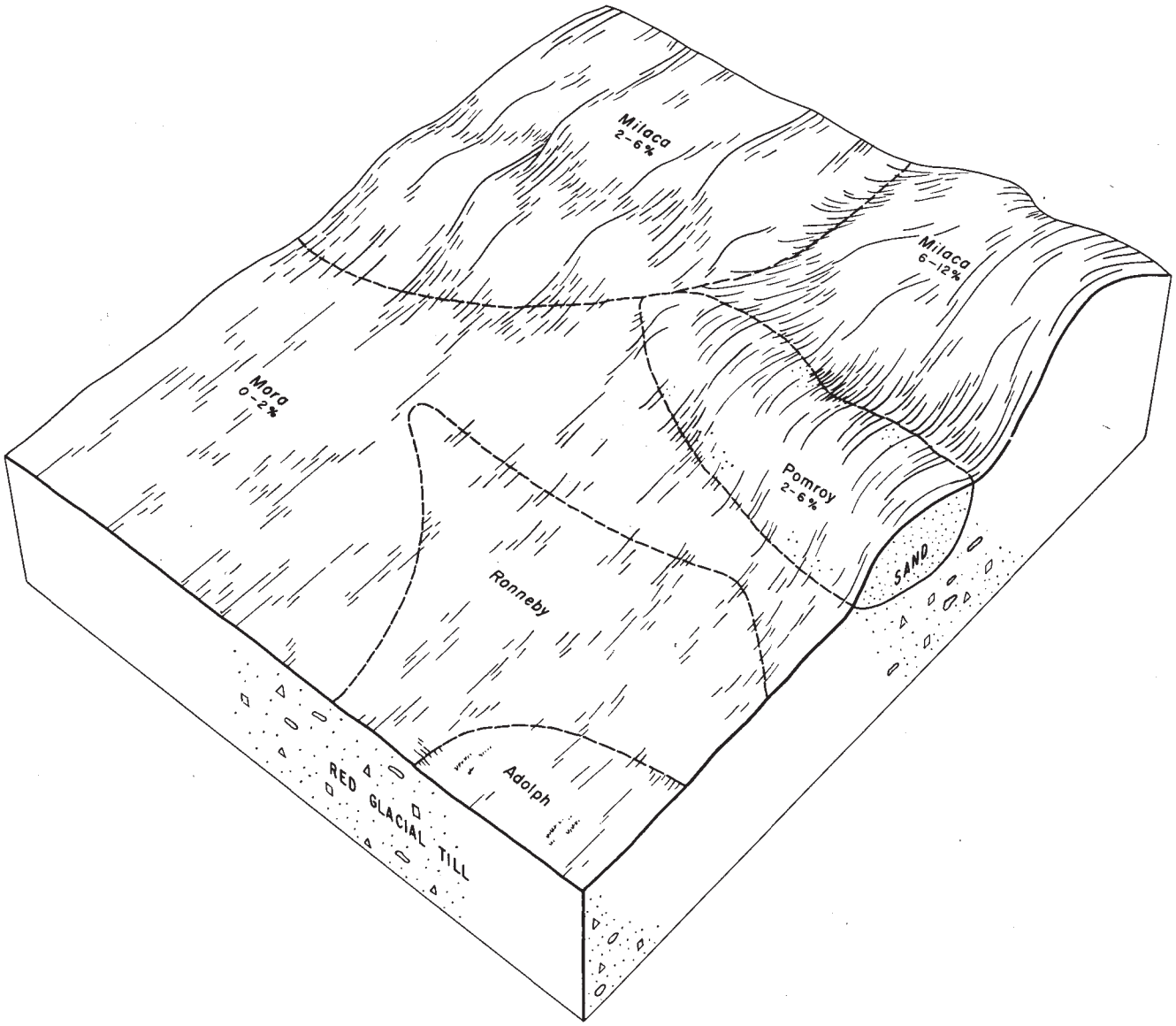

Figure 4.—**Representative pattern of soils in association 3.**

somewhat droughty. Emmert soils are excessively drained loamy sands and gravelly loamy sands. They occur as a complex with Hayden soils in this association, mainly in the eastern part of the county along the Anoka County line. Areas of this complex are morainic and hilly. The flat or depressional areas in this association consist of extremely variable, poorly drained and very poorly drained, medium-textured soils that are underlain by sand. Some are calcareous on the surface. Also in the depressions are moderately fine textured soils that are underlain by till.

All of the dominant soils in this association are susceptible to erosion. Braham and Emmert soils are somewhat droughty. The depressional areas are wet. Most farms are of the general type. Corn, alfalfa, soybeans, and small grain are grown. Some areas are uncleared and support good stands of mixed hardwoods. Much of the woodland is either hilly or flat and wet.

5. *Burkhardt-Chetek-Emmert association*

Undulating to very steep, shallow soils over acid gravel

This association occurs as one area in the eastern part of the county; much of it is along the eastern boundary. The area is parallel to U.S. Highway No. 169 and extends from Elk River to Zimmerman. This association occupies about 7 percent of the county.

This association consists predominantly of Burkhardt, Chetek, and Emmert soils (fig. 6) but includes peat bogs and small areas of Zimmerman, Milaca, and Isanti soils. Burkhardt soils are dark-colored, somewhat excessively drained sandy loams that are shallow over acid gravel. Chetek soils are light-colored, somewhat excessively drained sandy loams that are shallow over noncalcareous sand and gravel. Emmert soils are excessively drained loamy sands that are very shallow over noncalcareous gravel.

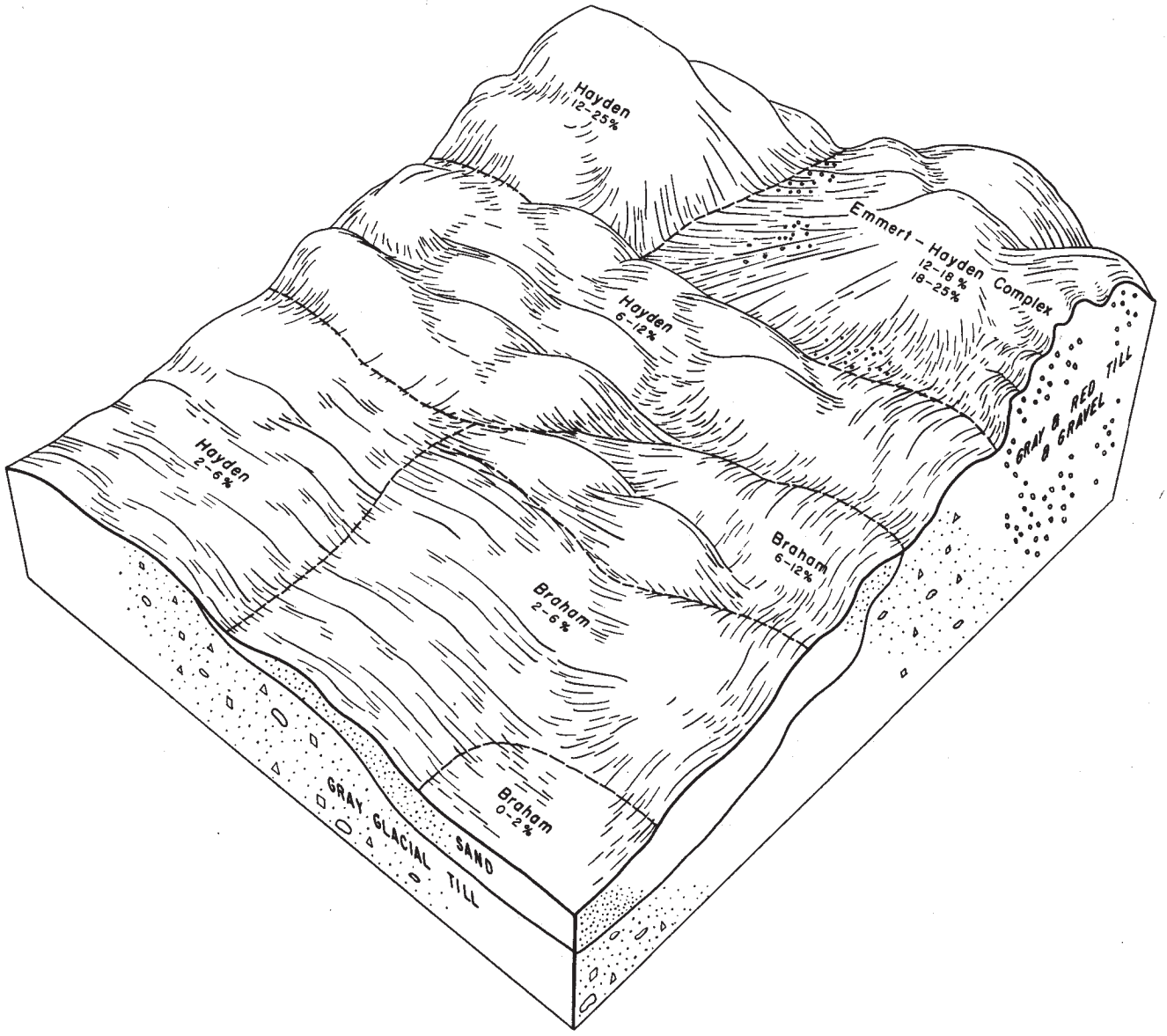

Figure 5.—**Representative pattern of major soils in association 4.**

For the most part, the soils of this association are droughty. The stronger slopes are subject to severe water erosion. Most farms are of the general type. Corn, small grain, hay, and pasture grasses are the main crops. Much of the association is uncleared and supports stands of scrub oak and low-quality mixed hardwoods. Most of the woodland is used as pasture.

Descriptions of the Soils

This section describes the soil series and mapping units of Sherburne County. The approximate acreage and the proportionate extent of each mapping unit are given in table 1.

A general description of each soil series is given, and this is followed by brief descriptions of the mapping units in that series. For full information on any one mapping unit, it is necessary to read the description of the soil series as well as the description of the mapping unit.

Following the name of each mapping unit is a symbol in parentheses. This symbol identifies the mapping unit on the detailed soil map. Listed at the end of the description of each mapping unit are the capability unit and the woodland group in which the mapping unit has been placed. The page on which each capability unit and each woodland group is described can be found readily by referring to the "Guide to Mapping Units" at the back of this survey.

Soil scientists, engineers, students, and others who want detailed descriptions of soil series should turn to the section "Formation and Classification of the Soils." Many terms used in the soil descriptions and other sections of this publication are defined in the Glossary.

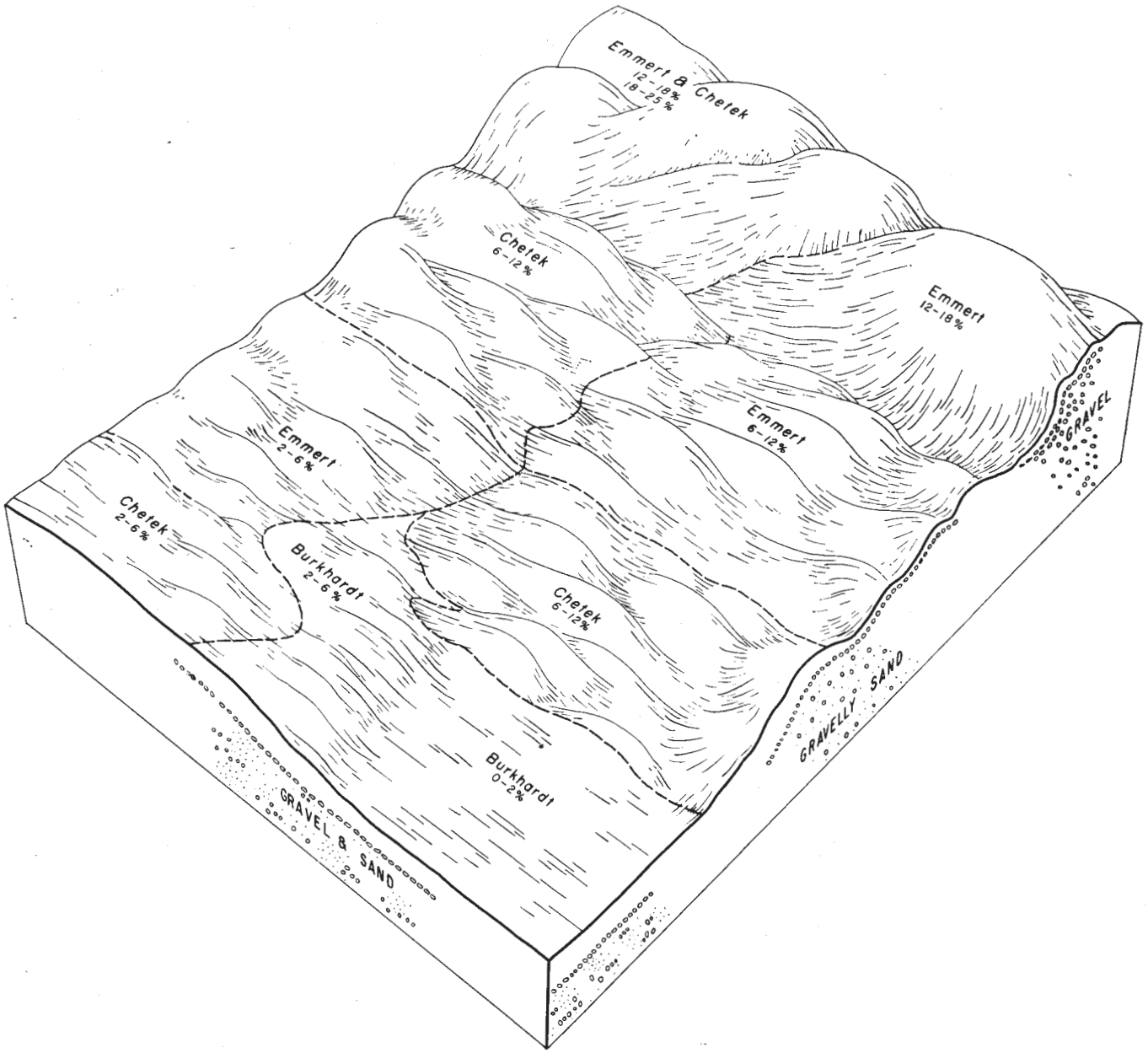

Figure 6.—**Representative pattern of soils in association 5.**

Adolph Series

The Adolph series consists of level and slightly depressional, deep, dark-colored, poorly drained soils. These soils developed in noncalcareous red glacial till. They occur within the ground moraine, mainly in the northern part of the county in Santiago and Blue Hill Townships. Following is a representative profile of Adolph loam in a cultivated area.

0 to 12 inches, black, friable loam; few, faint, very dark brown and brown mottles.
12 to 19 inches, very dark brown, friable loam; many, faint, very dark brown, dark grayish-brown, and grayish-brown mottles.
19 to 40 inches, dark-brown, friable heavy sandy loam; many, faint, brown and reddish-gray mottles.
40 to 48 inches, reddish-brown, slightly plastic heavy sandy loam; many, faint, reddish-brown and reddish-gray mottles.

These soils have a high water table. The moisture-holding capacity is moderate. The movement of air and water is moderately slow. The organic-matter content is high, and natural fertility is moderate. The reaction is neutral or slightly acid in the surface layer.

Adolph loam (Ap).—This soil occurs as both virgin and cultivated areas. Included in mapping were small areas where the surface is covered with a very thin layer of peat. The gradient is 0 to 2 percent.

Erosion is only slight. Excessive wetness is the major limitation. This soil is likely to compact if worked when wet. If adequately drained, it is suited to corn and grain but generally not to alfalfa. Adequate drainage and a

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TABLE 1.--APPROXIMATE ACREAGE AND PROPORTIONATE EXTENT OF THE SOILS

Soil	Area	Extent	Soil	Area	Extent
	Acres	Percent		Acres	Percent
Adolph loam	709	0.2	Emmert and Chetek soils, 18 to 25 percent slopes	1,878	0.7
Alluvial land	1,568	.6	Emmert and Chetek soils, 18 to 25 percent slopes, eroded	455	.2
Alluvial land, frequently flooded	6,135	2.2	Emmert-Hayden complex, 2 to 6 percent slopes, eroded	425	.1
Beach sand	106	(1/)	Emmert-Hayden complex, 6 to 12 percent slopes, eroded	641	.2
Becker loam, 0 to 2 percent slopes	1,095	.4	Emmert-Hayden complex, 12 to 18 percent slopes, eroded	1,268	.4
Becker loam, 2 to 6 percent slopes	431	.1	Emmert-Hayden complex, 18 to 25 percent slopes, eroded	1,071	.4
Braham loamy fine sand, 0 to 2 percent slopes	491	.2	Estherville sandy loam, 0 to 2 percent slopes	2,262	.8
Braham loamy fine sand, 2 to 6 percent slopes	1,067	.4	Estherville sandy loam, 0 to 2 percent slopes, wind eroded	441	.2
Braham loamy fine sand, 2 to 6 percent slopes, eroded	1,066	.4	Estherville sandy loam, 2 to 6 percent slopes	1,686	.6
Braham loamy fine sand, 6 to 12 percent slopes	585	.2	Estherville sandy loam, 2 to 6 percent slopes, eroded	898	.3
Braham loamy fine sand, 6 to 12 percent slopes, eroded	387	.1	Estherville sandy loam, 6 to 12 percent slopes	273	.1
Braham loamy fine sand, 12 to 18 percent slopes	549	.2	Estherville sandy loam, 6 to 12 percent slopes, eroded	444	.2
Burkhardt sandy loam, 0 to 2 percent slopes	1,438	.5	Fairhaven silt loam, light-colored variant, 0 to 2 percent slopes	107	(1/)
Burkhardt sandy loam, 2 to 6 percent slopes	490	.2	Fairhaven silt loam, light-colored variant, 2 to 6 percent slopes	150	.1
Burkhardt sandy loam, 2 to 6 percent slopes, eroded	390	.1	Hayden fine sandy loam, 0 to 2 percent slopes	298	.1
Chetek sandy loam, 0 to 2 percent slopes	628	.2	Hayden fine sandy loam, 2 to 6 percent slopes	1,836	.7
Chetek sandy loam, 2 to 6 percent slopes	1,570	.6	Hayden fine sandy loam, 2 to 6 percent slopes, moderately eroded	1,185	.4
Chetek sandy loam, 2 to 6 percent slopes, eroded	1,306	.5	Hayden fine sandy loam, 6 to 12 percent slopes	754	.3
Chetek sandy loam, 6 to 12 percent slopes	443	.2	Hayden fine sandy loam, 6 to 12 percent slopes, moderately eroded	1,010	.4
Chetek sandy loam, 6 to 12 percent slopes, eroded	548	.2	Hayden fine sandy loam, 6 to 12 percent slopes, severely eroded	152	.1
Chetek sandy loam, 6 to 12 percent slopes, severely eroded	400	.1	Hayden fine sandy loam, 12 to 18 percent slopes	490	.2
Dundas loam	439	.2	Hayden fine sandy loam, 12 to 18 percent slopes, moderately eroded	502	.2
Emmert gravelly loamy sand, 6 to 12 percent slopes	110	(1/)	Hayden fine sandy loam, 12 to 18 percent slopes, severely eroded	110	(1/)
Emmert gravelly loamy sand, 12 to 35 percent slopes	997	.4	Hayden fine sandy loam, 18 to 35 percent slopes	490	.2
Emmert loamy sand, 0 to 2 percent slopes	166	.1	Hubbard loamy sand, 0 to 2 percent slopes	11,844	4.2
Emmert loamy sand, 2 to 6 percent slopes	984	.3	Hubbard loamy sand, 0 to 2 percent slopes, wind eroded	21,282	7.6
Emmert loamy sand, 2 to 6 percent slopes, eroded	1,702	.6	Hubbard loamy sand, 2 to 6 percent slopes	6,276	2.2
Emmert loamy sand, 6 to 12 percent slopes	907	.3	Hubbard loamy sand, 2 to 6 percent slopes, eroded	14,565	5.2
Emmert loamy sand, 6 to 12 percent slopes, eroded	1,075	.4			
Emmert loamy sand, 6 to 12 percent slopes, severely eroded	399	.1			
Emmert and Chetek soils, 12 to 18 percent slopes	1,388	.5			
Emmert and Chetek soils, 12 to 18 percent slopes, eroded	783	.3			

See footnote at end of table.

TABLE 1.--APPROXIMATE ACREAGE AND PROPORTIONATE EXTENT OF THE SOILS--CONTINUED

Soil	Area	Extent	Soil	Area	Extent
	Acres	Percent		Acres	Percent
Hubbard loamy sand, 2 to 6 percent slopes, severely eroded	506	0.2	Milaca fine sandy loam, 18 to 25 percent slopes	99	(1/)
Hubbard loamy sand, 6 to 12 percent slopes	2,107	.7	Mora loam, 0 to 2 percent slopes	997	.4
Hubbard loamy sand, 6 to 12 percent slopes, eroded	1,967	.7	Mora loam, 2 to 6 percent slopes	141	(1/)
Hubbard loamy sand, 6 to 12 percent slopes, severely eroded	454	.2	Peat and muck, deep	24,613	8.8
Hubbard loamy sand, 12 to 25 percent slopes	829	.3	Peat and muck, shallow over loam	845	.3
Hubbard loamy sand, 12 to 25 percent slopes, eroded	216	.1	Peat and muck, shallow over sand	6,945	2.5
Hubbard sandy loam, 0 to 2 percent slopes	7,209	2.6	Peat-Lino complex	585	.2
Hubbard sandy loam, 0 to 2 percent slopes, wind eroded	4,315	1.5	Pomroy loamy fine sand, 0 to 2 percent slopes	136	(1/)
Hubbard sandy loam, 2 to 6 percent slopes	912	.3	Pomroy loamy fine sand, 2 to 6 percent slopes	181	.1
Hubbard sandy loam, 2 to 6 percent slopes, eroded	1,573	.6	Ronneby loam	1,398	.5
Hubbard sandy loam, 6 to 12 percent slopes, eroded	233	.1	Salida complex, 0 to 6 percent slopes	2,991	1.1
Isanti loamy fine sand	12,063	4.3	Salida complex, 0 to 6 percent slopes, eroded	4,704	1.7
Lino loamy fine sand, 0 to 2 percent slopes	8,041	2.9	Salida complex, 6 to 12 percent slopes	353	.1
Lino loamy fine sand, 0 to 2 percent slopes, wind eroded	584	.2	Salida complex, 6 to 12 percent slopes, eroded	418	.1
Lino loamy fine sand, 2 to 6 percent slopes	375	.1	Salida complex, 12 to 25 percent slopes	910	.3
Lino loamy fine sand, loamy substratum, 0 to 2 percent slopes	1,176	.4	Wadena loam, 0 to 2 percent slopes	407	.1
Loamy wet land	2,932	1.0	Zimmerman loamy fine sand, 0 to 2 percent slopes	6,142	2.2
Marsh	10,302	3.7	Zimmerman loamy fine sand, 0 to 2 percent slopes, wind eroded	11,296	4.0
Milaca fine sandy loam, 0 to 2 percent slopes	260	.1	Zimmerman loamy fine sand, 2 to 6 percent slopes	15,525	5.5
Milaca fine sandy loam, 2 to 6 percent slopes	464	.2	Zimmerman loamy fine sand, 2 to 6 percent slopes, eroded	22,681	8.1
Milaca fine sandy loam, 2 to 6 percent slopes, moderately eroded	341	.1	Zimmerman loamy fine sand, 6 to 12 percent slopes	7,726	2.8
Milaca fine sandy loam, 6 to 12 percent slopes, eroded	249	.1	Zimmerman loamy fine sand, 6 to 12 percent slopes, eroded	5,764	2.1
Milaca fine sandy loam, 12 to 18 percent slopes	88	(1/)	Zimmerman fine sand, 12 to 25 percent slopes	4,798	1.7
			Gravel pits, borrow pits, quarries, and dumps	322	.1
			Total	280,320	100.0

1/ Less than 0.05 percent.

cropping system that preserves tilth and supplies organic matter are the main management needs. Most of the acreage is either wooded, brushy, undrained pasture or poor-quality woodland. The rest is cropland. (Capability unit IIIw–1; woodland group 8)

Alluvial Land

Alluvial land (Ad) consists of soil material recently deposited by flooding streams on flood plains and low terraces. The material ranges from loamy sand to silt loam in texture, and the deposits commonly consist of strata of silt, sandy loam, sand, and gravel. In places the surface appears to be corrugated, and in many places it is covered with a thin layer of peat. The depth of the soil material varies. Internal drainage ranges from good to poor. For the most part, this land type supports native stands of mixed hardwoods. A small acreage is farmed. (Capability unit IIw–2; woodland group 9)

Alluvial land, frequently flooded (Af) is similar to Alluvial land except that it is frequently flooded. (Capability unit VIw–1; woodland group 9)

Beach Sand

Beach sand (Bc) consists of nearly level or gently sloping areas of loose sandy material along some of the lakes in the county. These areas are generally not used for agriculture. (Capability unit VIs–3; woodland group 1)

Becker Series

The Becker series consists of nearly level or undulating, moderately well drained or well drained soils that are underlain by sand at a depth of 24 to 42 inches. These soils developed in deposits of alluvium. They occur on high terraces along the Mississippi River. Following is a representative profile of Becker loam in a cultivated area.

0 to 6 inches, black, very friable loam.
6 to 26 inches, black, friable very fine sandy loam; grades to dark gray in the lower part.
26 to 34 inches, very dark grayish-brown, very friable very fine sandy loam grading to loamy very fine sand with depth.
34 to 48 inches, brown, very friable loamy very fine sand.

The moisture-holding capacity of these soils is moderate. The movement of air and water is moderate. The organic-matter content is high, and natural fertility is moderate. The reaction is neutral throughout the profile.

Becker loam, 0 to 2 percent slopes (BeA).—Virgin areas of this soil are uneroded. Most of the cultivated acreage is only slightly eroded, but in spots more than a third of the original surface layer has been removed.

This is a productive soil that is suited to all crops commonly grown in the county. A slightly less than adequate moisture-holding capacity and a slight hazard of wind erosion are the major limitations. Conserving moisture, controlling erosion, maintaining fertility, preserving tilth, and supplying organic matter are the main management needs. Most of the acreage is cropland. The rest is woodland or permanent pasture. (Capability unit IIs–1; woodland group 4)

Becker loam, 2 to 6 percent slopes (BeB).—Virgin areas of this soil are uneroded. Most of the cultivated acreage is only slightly eroded, but in spots more than a third of the original surface layer has been removed. The topography is gently sloping or undulating. Slopes are short.

This is a productive soil that is suited to all crops commonly grown in the county. A slightly less than adequate moisture-supplying capacity and a moderate hazard of wind erosion are the major limitations. Conserving moisture, controlling erosion, preserving tilth, maintaining fertility, and supplying organic matter are the main management needs. Most of the acreage is cropland. The rest is woodland or permanent pasture. (Capability unit IIs–1; woodland group 4)

Braham Series

The Braham series consists of nearly level to steep, well drained or moderately well drained soils. These soils are underlain by clay loam glacial till or silty lacustrine material at a depth of 24 to 42 inches. They occur on the edges of the islands of glacial till that project through the sand plain north of Becker and Elk River and near Santiago. Following is a representative profile of Braham loamy fine sand in a cultivated area.

0 to 8 inches, very dark brown, loose loamy fine sand.
8 to 29 inches, dark grayish-brown, loose fine sand.
29 to 36 inches, brown, very firm silty clay loam; many, faint, brown and yellowish-brown mottles.
36 to 40 inches, light brownish-gray, firm silty clay loam; many distinct, strong-brown and yellowish-brown mottles.
40 to 44 inches, grayish-brown, very firm silty clay loam; many, faint, yellowed-brown and dark yellowish-brown mottles.
44 to 54 inches, brown, friable silt loam.

The movement of air and water is rapid in the upper part of these soils and moderate in the lower part. The moisture-holding capacity is low. The organic-matter content is low, and natural fertility is low. The reaction is strongly acid in the surface layer.

Braham loamy fine sand, 0 to 2 percent slopes (BrA).—Virgin areas of this soil are uneroded. Most of the cultivated acreage is only slightly eroded, but in spots more than a third of the original surface layer has been removed. Included in mapping were small areas that have a thin surface layer of fine sandy loam.

This soil is suited to most crops grown in the county. Yields are fair. Low moisture-holding capacity and low natural fertility are the major limitations. Conserving moisture, increasing fertility, and controlling wind erosion are the main management needs. Most of the acreage is cropland. The rest is oak forest or permanent pasture. (Capability unit IIIs–2; woodland group 5)

Braham loamy fine sand, 2 to 6 percent slopes (BrB).—Virgin areas of this soil are uneroded. Most of the cultivated acreage is only slightly eroded, but spots on the crests of slopes have lost more than a third of their original surface layer through wind erosion. The topography is gently sloping or undulating. Slopes generally are short. Included in mapping were spots of a deep sandy soil and small areas in shallow swales where the surface layer is fine sandy loam.

This soil is suited to most crops commonly grown in the county. Yields are fair. Low moisture-holding capacity and low natural fertility are the major limitations. Conserving moisture, increasing fertility, and controlling wind erosion are the main management needs. Most of the acreage is cropland. The rest is oak forest or permanent pasture. (Capability unit IIIs–2; woodland group 5)

Braham loamy fine sand, 2 to 6 percent slopes, eroded (BrB2).—Between one-third and two-thirds of the original surface layer of this soil has been removed by wind erosion. On slight rises on the crests of slopes, the surface layer is lighter colored in places and the sand appears looser because some of the fine silt and clay particles have blown away. The topography is gently sloping or undulating. Slopes generally are short. Included in mapping were deep sandy spots and small areas in shallow swales where the surface layer is thin and is fine sandy loam in texture.

This soil is suited to most crops commonly grown in the county. Yields are fair. Low moisture-holding capacity and low natural fertility are the major limitations. Increasing fertility, conserving moisture, and controlling erosion are the main management needs. Most of the

acreage is cropland. (Capability unit IIIs–2; woodland group 5)

Braham loamy fine sand, 6 to 12 percent slopes (BrC).—This soil has a surface layer slightly thinner and slightly lighter colored than that in the profile described for the series. Virgin areas are uneroded, and cultivated areas are only slightly eroded. The topography is sloping or rolling. Slopes generally are short and complex. Included in mapping were sandy spots on side slopes where the sand is more than 48 inches thick.

This soil can be used for most crops commonly grown in the county, but yields are poor. Low moisture-holding capacity and low natural fertility are the main limitations. Conserving moisture, increasing fertility, supplying organic matter, and controlling erosion are the main management needs. Most of the acreage is oak forest or permanent pasture. Only a small acreage is cropland. (Capability unit IVs–2; woodland group 5)

Braham loamy fine sand, 6 to 12 percent slopes, eroded (BrC2).—This soil has a surface layer slightly thinner and slightly lighter colored than that in the profile described for the series. Between one-third and two-thirds of the original surface layer has been removed or shifted by wind erosion. On the crests of slopes, most of the original surface layer is gone and the sandy subsoil has been turned up in plowing. The topography is sloping or rolling. Slopes generally are short and complex. Included in mapping were sandy spots on side slopes where the sand is more than 48 inches thick.

This soil can be used for most crops commonly grown in the county, but yields are poor. Low moisture-holding capacity and low natural fertility are the major limitations. Conserving moisture, increasing fertility, and controlling erosion are the main management needs. Most of the acreage is cropland. (Capability unit IVs–2; woodland group 5)

Braham loamy fine sand, 12 to 18 percent slopes (BrD).—This soil has a surface layer slightly thinner and slightly lighter colored than that in the profile described for the series. Virgin areas are uneroded, and cultivated areas are only slightly eroded. The topography is moderately steep or hilly. Slopes generally are short and complex. Included in mapping were sandy spots on side slopes where the sand is more than 48 inches thick. Also included were about 60 acres where the soil is moderately eroded and about 95 acres where the slope is 18 to 25 percent.

This soil is suitable for meadow, pasture, and woodland, but it is too steep and too droughty to be suitable for cropland. Low moisture-holding capacity and low natural fertility are the major limitations. Erosion is a hazard. Cultivated fields should be seeded to permanent vegetation. Most of the acreage is oak forest or permanent pasture. The rest is cropland. (Capability unit VIs–2; woodland group 5)

Burkhardt Series

The Burkhardt series consists of nearly level or undulating, somewhat excessively drained soils that are underlain by gravel at a depth of 18 to 36 inches. These soils developed in noncalcareous, gravelly glacial outwash. Some areas occur in the rough, morainic hills in the eastern part of the county in Elk River and Livonia Townships, and others occur in the northwestern part of the county in Haven and Palmer Townships. Following is a representative profile of Burkhardt sandy loam in a virgin site.

0 to 6 inches, black, very friable sandy loam.
6 to 13 inches, very dark brown, very friable sandy loam; dark grayish-brown blotches.
13 to 22 inches, dark-brown, very friable sandy loam.
22 to 28 inches, dark-brown, very friable loamy sand; many cobblestones.
28 to 36 inches, dark-brown to brown, loose, coarse gravel.

These soils warm up early in spring and are easy to work. The moisture-holding capacity is low. The movement of air and water is rapid. The organic-matter content is medium to high, and natural fertility is moderate. The reaction is strongly acid in the surface layer.

Burkhardt sandy loam, 0 to 2 percent slopes (BuA).—Virgin areas of this soil are uneroded. Most of the cultivated acreage is only slightly eroded, but in spots from one-third to two-thirds of the original surface layer has been removed.

This soil is suited to most crops commonly grown in the county. Yields are fair. Wind erosion is a hazard in cultivated areas. Low moisture-holding capacity is a serious limitation. Conserving moisture, increasing fertility, and controlling erosion are the main management needs. Most of the acreage is cropland, part of it is oak forest, and the rest is permanent pasture. (Capability unit IIIs–1; woodland group 2)

Burkhardt sandy loam, 2 to 6 percent slopes (BuB).—Virgin areas of this soil are uneroded. Most of the cultivated acreage is only slightly eroded, but spots on the crests of slopes have lost more than a third of the original surface layer through wind and water erosion and the rest has been mixed with the subsoil in plowing. The topography is gently sloping or undulating. Slopes generally are short.

This soil is suited to most crops commonly grown in the county. Yields are fair. Both wind and water erosion are hazards in cultivated areas. Low moisture-holding capacity is a serious limitation. Controlling erosion, conserving moisture, and increasing fertility are the main management needs. Most of the acreage is cropland, part of it is oak forest, and the rest is permanent pasture. (Capability unit IIIe–2; woodland group 2)

Burkhardt sandy loam, 2 to 6 percent slopes, eroded (BuB2).—Between one-third and two-thirds of the original surface layer of this soil has been removed by wind and water erosion. The remaining material has been mixed with material from the subsoil, and the present surface layer is dark grayish brown instead of black. In spots on the crests of slopes, most of the original surface layer is gone and the subsoil has been turned up in plowing. A few pebbles and cobblestones occur in the surface layer in some areas, and many occur on the crests of eroded slopes. The topography is gently sloping or undulating. Slopes generally are short. Included in mapping were spots where as much as 36 inches of the dark-colored loam or sandy loam has been removed from the crest of slopes and deposited at the base.

This soil is suited to most crops commonly grown in the county. Yields are fair. Both wind and water ero-

sion are hazards. Low moisture-holding capacity is a serious limitation. Controlling erosion, conserving moisture, and increasing fertility are the main management needs. (Capability unit IIIe–2; woodland group 2)

Chetek Series

The Chetek series consists of nearly level to rolling, somewhat excessively drained soils that are underlain by noncalcareous, gravelly, glacial outwash at a depth of 18 to 48 inches. These soils occur in the rough morainic areas in the eastern part of the county in Elk River and Livonia Townships. Following is a representative profile of Chetek sandy loam in a virgin site.

0 to 1 inch, black to very dark brown, very friable sandy loam.
1 to 17 inches, brown, very friable sandy loam.
17 to 20 inches, reddish-brown, firm sandy loam.
20 to 23 inches, dark reddish-brown, firm fine sandy loam.
23 to 42 inches, brown, loose sand and coarse sand.
42 to 48 inches, brown, loose, noncalcareous gravel.

The moisture-holding capacity of these soils is low or very low. The movement of air and water is rapid. The organic-matter content is low, and natural fertility is low. The reaction is medium acid in the surface layer.

Chetek sandy loam, 0 to 2 percent slopes (ChA).—Virgin areas of this soil are uneroded. Most of the cultivated acreage is only slightly eroded, but in spots, between 3 and 6 inches of the original surface layer has been removed.

This soil is suited to most crops commonly grown in the county. Yields are fair. Wind erosion is a hazard in cultivated areas. Low moisture-holding capacity and low natural fertility are serious limitations. Conserving moisture, increasing fertility, and controlling erosion, are the main management needs. Most of the acreage is cropland. The rest is oak forest or permanent pasture. (Capability unit IIIs–1; woodland group 2)

Chetek sandy loam, 2 to 6 percent slopes (ChB).—Virgin areas of this soil are uneroded. Most of the cultivated acreage is only slightly eroded, but some spots on the crest of slopes have lost between 3 and 6 inches of the original surface layer through wind and water erosion. The topography is gently sloping or undulating. Slopes generally are short.

This soil is suited to most crops commonly grown in the county. Yields are fair. Both wind and water erosion are hazards in cultivated areas. Low moisture-holding capacity and low natural fertility are serious limitations. Controlling erosion, conserving moisture, and increasing fertility are the main management needs. Most of the acreage is cropland, part of it is oak forest, and the rest is permanent pasture. (Capability unit IIIe–2; woodland group 2)

Chetek sandy loam, 2 to 6 percent slopes, eroded (ChB2).—This soil has lost between 3 and 6 inches of its original surface layer through wind and water erosion. In spots on the crests of slopes most of the original surface layer is gone, the dark reddish-brown subsoil has been turned up by plowing, and gravelly material is exposed. The topography is gently sloping or undulating. Slopes generally are short.

This soil is suited to most crops commonly grown in the county. Yields are fair. Both wind and water erosion are hazards. Low moisture-holding capacity and low natural fertility are serious limitations. Controlling erosion, conserving moisture, and increasing fertility are the main management needs. Most of the acreage is cropland. (Capability unit IIIe–2; woodland group 2)

Chetek sandy loam, 6 to 12 percent slopes (ChC).—Virgin areas of this soil are uneroded, and cultivated areas are only slightly eroded. The topography is sloping or rolling. Slopes generally are short.

This soil can be used for most crops commonly grown in the county, but yields are poor. Low moisture-holding capacity and low natural fertility are serious limitations. Controlling erosion, conserving moisture, increasing fertility, and supplying organic matter are the main management needs in cultivated areas. Most of the acreage is oak forest or permanent pasture. Only a small acreage is cropland. (Capability unit IVe–2; woodland group 2)

Chetek sandy loam, 6 to 12 percent slopes, eroded (ChC2).—This soil has lost between 3 and 6 inches of its original surface layer through erosion. In spots on the crests of the slopes, most of the original surface layer is gone, the reddish-brown subsoil has been turned up in plowing, and gravelly material is exposed. There are a few rills on side slopes. The topography is sloping or rolling. Slopes generally are short.

This soil can be used for most crops commonly grown in the county, but yields are poor. Low moisture-holding capacity and low natural fertility are serious limitations. Controlling erosion, conserving moisture, increasing fertility, and supplying organic matter are the main management needs. Most of the acreage is cropland. (Capability unit IVe–2; woodland group 2)

Chetek sandy loam, 6 to 12 percent slopes, severely eroded (ChC3).—This soil has lost much of its original surface layer through erosion. In many places, much of the fine material has been washed away and the present surface layer is gravelly sandy loam. On the crests of slopes the dark reddish-brown subsoil is exposed. Rills are common on side slopes. The topography is sloping or rolling. Slopes generally are short.

This soil is suitable for meadow, pasture, and woodland, but it is too droughty to be suitable for cropland. Yields of cultivated crops are very poor. The erosion hazard is severe. Very low moisture-holding capacity and low natural fertility are serious limitations. Nevertheless, most of the acreage is cropland. Controlling erosion, conserving moisture, and increasing fertility are the main management needs. Cultivated fields should be seeded to permanent pasture. (Capability unit VIe–2; woodland group 2)

Dundas Series

The Dundas series consists of nearly level or undulating, deep, somewhat poorly drained soils. These soils developed in calcareous glacial till. They occur north of Becker and Elk River and also on the till islands that project through the sand plain in the northwestern part of the county. Following is a representative profile of Dundas loam in a cultivated area.

0 to 7 inches, very dark gray to very dark brown, friable loam.
7 to 11 inches, dark-gray, friable fine sandy loam; fine dark-brown, dark yellowish-brown, and brown mottles.

11 to 19 inches, slightly plastic heavy loam unevenly mottled with grayish brown, dark grayish brown, and dark brown.
19 to 23 inches, dark grayish-brown, sticky and plastic clay loam; many, faint, dark-brown to dark yellowish-brown mottles.
23 to 32 inches, mottled, sticky and plastic clay loam; mottles are many, faint, dark brown, dark grayish brown, and dark yellowish brown.
32 to 42 inches, olive-gray, sticky and plastic clay loam; many, distinct, light olive-brown mottles.

The moisture-holding capacity of these soils is moderate. The movement of air and water is moderately slow. The organic-matter content is medium, and natural fertility is moderate. The reaction is slightly acid in the surface layer.

Dundas loam (Du).—In virgin areas this soil has a surface layer slightly thinner and slightly darker colored than that in the profile described for the series. Virgin areas are uneroded, and cultivated areas are only slightly eroded. The gradient is 0 to 4 percent. Included in mapping were small areas where the topography is undulating. In these areas the low spots are wetter than is typical for this soil and the crests of slopes are better drained.

This soil is well suited to most crops grown in the county but is likely to compact if worked when wet. It is not suited to alfalfa. Establishing and maintaining stands of alfalfa without drainage, fertilization, and the application of lime is likely to be difficult. Wetness is the major limitation. Adequate drainage and a cropping system that increases fertility, supplies organic matter, and preserves tilth are the main management needs. Most of the acreage is cropland, part of it is woodland, and the rest is permanent pasture. (Capability unit IIw–1; woodland group 8)

Emmert Series

The Emmert series consists of nearly level to very steep, excessively drained soils that are underlain by stony and gravelly, noncalcareous glacial drift at a depth of 6 to 18 inches. They occur in the morainic area in the eastern part of the county, chiefly in Elk River and Livonia Townships, and also as small areas along the Sherburne-Benton County line. Following is a representative profile of Emmert gravelly loamy sand in a virgin site.

0 to 2 inches, black, very friable gravelly loamy sand.
2 to 6 inches, very dark grayish-brown, very friable gravelly loamy sand; cobblestones.
6 to 48 inches, brown to dark-brown, loose coarse gravel.

The moisture-holding capacity of these soils is very low. The movement of air and water is very rapid. The organic-matter content is low, and natural fertility is low. The reaction is strongly acid throughout.

Emmert gravelly loamy sand, 6 to 12 percent slopes (EgC).—Most of this soil is uncultivated and uneroded. A small acreage is slightly or moderately eroded, and on the crests of the slopes in cultivated areas, most of the original surface layer is gone and gravelly spots are exposed. The topography is sloping or rolling. Slopes generally are short and complex.

This soil is suitable for meadow, pasture, and woodland, but it is too steep and too droughty to be suitable for cropland. Very low moisture-holding capacity and low natural fertility are the major limitations. Erosion is a serious hazard. Cultivated fields should be seeded to permanent vegetation. Most of the acreage is either oak forest or permanent pasture. (Capability unit VIs–1; woodland group 3)

Emmert gravelly loamy sand, 12 to 35 percent slopes (EgE).—This soil consists mainly of uneroded virgin areas but includes a small acreage that has been eroded. On the crests of slopes in cultivated areas, the original surface layer is gone and the gravelly or cobbly subsoil is exposed. The topography is moderately steep to very steep. Slopes generally are short and complex.

This soil is suitable for woodland but is too steep and too droughty to be suitable for either cropland or pasture. At best, the yield of pasture grasses is poor. Very low moisture-holding capacity is the major limitation. The erosion hazard is severe. Most of the acreage is either oak forest or permanent pasture. (Capability unit VIIs–1; woodland group 3)

Emmert loamy sand, 0 to 2 percent slopes (ElA).—Virgin areas of this soil are uneroded, and most cultivated areas are only slightly eroded. Included in mapping was about 50 acres where wind erosion has removed between one-third and two-thirds of the original surface layer. The present surface layer of this eroded acreage is brown instead of black, and the gravelly subsoil is exposed.

This soil can be used for most crops commonly grown in the county, but yields are poor. Very low moisture-holding capacity and low natural fertility are the major limitations. Wind erosion is a hazard. Nevertheless, much of the acreage is cropland. The rest is oak forest or permanent pasture. Conserving moisture, increasing fertility, and controlling wind erosion are the main management needs. (Capability unit IVs–1; woodland group 3)

Emmert loamy sand, 2 to 6 percent slopes (ElB).—Virgin areas of this soil are uneroded. Most of the cultivated acreage is only slightly eroded, but spots on the crests of slopes have lost more than a third of the original surface layer through wind and water erosion. In these spots, the present surface layer is brown and the gravelly loamy sand subsoil is exposed. The topography is gently sloping or undulating. Slopes generally are short. Included in mapping was approximately 60 acres where the surface layer is gravelly and is very shallow over gravel.

This soil can be used for most crops commonly grown in the county, but yields are poor. Very low moisture-holding capacity and low natural fertility are serious limitations. Wind erosion is a hazard. Nevertheless, much of the acreage is cropland. The rest is either oak forest or permanent pasture. Conserving moisture, increasing fertility, and controlling wind erosion are the main management needs. (Capability unit IVs–1; woodland group 3)

Emmert loamy sand, 2 to 6 percent slopes, eroded (ElB2).—Between one-third and two-thirds of the original surface layer of this soil has been removed by wind or water erosion, and the rest has been mixed with the subsoil in plowing. On the crests of slopes, more than two-thirds of the original surface layer is gone and the subsoil

has been turned up in plowing. A few small areas of gravelly or cobbly material are exposed. The topography is gently sloping or undulating. Slopes generally are short.

This soil can be used for most crops commonly grown in the county, but yields are poor. Very low moisture-holding capacity and low natural fertility are the major limitations. Wind erosion and sandblasting are hazards. Nevertheless, most of the acreage is cropland. Conserving moisture, increasing fertility, and controlling erosion are the main management needs. (Capability unit IVs–1; woodland group 3)

Emmert loamy sand, 6 to 12 percent slopes (ElC).—Virgin areas of this soil are uneroded. Most of the cultivated acreage is only slightly eroded, but spots on the crests of slopes have lost more than a third of the original surface layer through water erosion and the subsoil has been turned up in plowing. The topography is sloping or rolling. Slopes generally are short.

This soil is marginal for cultivated crops. Yields are poor. Very low moisture-holding capacity and low natural fertility are the major limitations. Erosion is a hazard. Conserving moisture, increasing fertility, and controlling erosion are the main management needs. Most of the acreage is either oak forest or permanent pasture. Only a small acreage is cropland. (Capability unit IVs–1; woodland group 3)

Emmert loamy sand, 6 to 12 percent slopes, eroded (ElC2).—Erosion has removed between one-third and two-thirds of the original surface layer from this soil, and plowing has mixed the rest with material from the subsoil. On the crests of slopes, more than two-thirds of the original surface layer is gone and the subsoil has been turned up in plowing. A few small gravelly or cobbly spots are exposed. Rills are common on side slopes. The topography is sloping or rolling. Slopes generally are short.

This soil is marginal for cultivated crops. Yields are poor. Very low moisture-holding capacity and low natural fertility are the major limitations. Erosion is a hazard. Nevertheless, most of the acreage is cropland. Conserving moisture, increasing fertility, and controlling erosion are the main management needs. (Capability unit IVs–1; woodland group 3)

Emmert loamy sand, 6 to 12 percent slopes, severely eroded (ElC3).—Erosion has removed more than two-thirds of the original surface layer from this soil, and plowing has mixed the rest with gravelly material from the subsoil. The present surface layer is gravelly loamy sand. All of the original surface layer is gone from the crests of some slopes, and either gravelly material or a pavement of cobblestones and gravel is exposed. Rills are common on side slopes. The topography is sloping or rolling. Slopes generally are short.

This soil is suitable for meadow, pasture, and woodland, but it is too droughty to be suitable for cropland. Yields of cultivated crops are very poor. Very low moisture-holding capacity and low natural fertility are the major limitations. The erosion hazard is severe. Nevertheless, most of the acreage is cropland. Conserving moisture, increasing fertility, and controlling erosion are the main management needs. Cultivated fields should be seeded to permanent vegetation. (Capability unit VIs–1; woodland group 3)

Emmert and Chetek soils, 12 to 18 percent slopes (EmD).—The solum of these soils is thinner than that in the profile described for either Emmert loamy sand or Chetek sandy loam. Virgin areas are uneroded, and cultivated areas are only slightly eroded. The topography is moderately steep or hilly. Slopes are complex.

These soils are suitable for meadow, pasture, or woodland, but they are too steep and too droughty to be suitable for cropland. Very low moisture-holding capacity and low natural fertility are the major limitations. Erosion is a hazard. Cultivated fields should be seeded to permanent vegetation. Most of the acreage is either oak forest or permanent pasture. Only a small acreage is cropland. (Capabilty unit VIs–1; woodland group 3)

Emmert and Chetek soils, 12 to 18 percent slopes, eroded (EmD2).—Between one-third and two-thirds of the original surface layer of these soils has been removed by erosion, and the rest has been mixed with gravelly material from the subsoil in plowing. In many places the present surface layer is gravelly loamy sand or gravelly sandy loam. Most of the original surface layer is gone from the crests of slopes, and the gravelly subsoil is exposed. In several spots, all the finer material has been washed away and and a pavement of cobblestones and gravel is at the surface. Rills are common on side slopes. The topography is moderately steep or hilly. Slopes are complex.

This soil is suitable for meadow, pasture, and woodland, but it is too droughty to be suitable for cropland. Yields of cultivated crops are very poor. Very low moisture-holding capacity and low natural fertility are the major limitations. The erosion hazard is severe. Nevertheless, most of the acreage is cropland. Conserving moisture, increasing fertility, and controlling erosion are the main management needs. Cultivated fields should be seeded to permanent vegetation. (Capability unit VIs–1; woodland group 3)

Emmert and Chetek soils, 18 to 25 percent slopes (EmE).—For the most part, these soils have not been cultivated, and consequently they have been little affected by erosion. Their solum is thinner than that in the profile described for either Emmert loamy sands or Chetek sandy loams, and their surface layer, particularly on the crests of the slopes, is somewhat shallower over gravel. There are a few scattered boulders and cobblestones. Slopes are complex.

These soils are suitable for woodland and pasture, but they are too steep and too droughty to be suitable for cropland. Very low moisture-holding capacity is the major limitation. Erosion is a hazard. Most of the acreage is either oak forest or permanent pasture. (Capability unit VIIs–1; woodland group 3)

Emmert and Chetek soils, 18 to 25 percent slopes, eroded (EmE2).—These soils are shallower over gravel than is typical of either Emmert or Chetek soils. Between one-third and two-thirds of their original surface layer has been removed by erosion. The rest has been mixed with gravelly material from the subsoil in plowing, and in many places the present surface layer is gravelly loamy sand or gravelly sandy loam. The crests of slopes have been eroded to the degree that they have lost all of

their original surface layer and are now covered with a pavement of cobblestones or gravel. Ordinarily, the upper part of the profile contains many cobblestones. Rills and small gullies are common on side slopes. The topography is steep. Slopes are complex.

These soils are suitable for woodland but are too steep and too droughty to be suitable for cropland. Very low moisture-holding capacity is the major limitation. The erosion hazard is severe. Nevertheless, most of the acreage is cropland. Cultivated fields should be seeded to permanent vegetation. (Capability unit VIIs–1; woodland group 3)

Emmert-Hayden complex, 2 to 6 percent slopes, eroded (ErB2).—Virgin areas of this complex are uneroded and have a few scattered boulders and cobblestones on the surface. In cultivated areas up to two-thirds of the original surface layer is gone. Pockets of gravel are exposed on the crests of slopes, and gravel mixed with glacial till is exposed in various spots. The topography is undulating. Slopes generally are short.

These soils can be used for most crops commonly grown in the county, but yields are poor. Erosion is a hazard. Very low moisture-holding capacity and low natural fertility are serious limitations. Controlling erosion, conserving moisture, and increasing fertility are the main management needs. Much of the acreage is cropland, part of it is woodland, and the rest is permanent pasture. (Capability unit IIIe–2; woodland group 2)

Emmert-Hayden complex, 6 to 12 percent slopes, eroded (ErC2).—Virgin areas of this complex are uneroded and have a few scattered boulders and cobblestones on the surface. In cultivated areas up to two-thirds of the original surface layer is gone. Pockets of gravel are exposed on the crests of slopes, and gravel mixed with glacial till is exposed in various spots. The topography is rolling. Slopes generally are short and complex.

These soils can be used for most crops commonly grown in the county, but yields are poor. Erosion is a hazard. Very low moisture-holding capacity and low natural fertility are serious limitations. Nevertheless, much of the acreage is cropland. Controlling erosion, conserving moisture, and increasing fertility are the main management needs in cultivated areas. (Capability unit IVe–2; woodland group 2)

Emmert-Hayden complex, 12 to 18 percent slopes, eroded (ErD2).—Virgin areas of this complex are uneroded and have scattered boulders and cobblestones on the surface. In cultivated areas up to two-thirds of the original surface layer is gone. Pockets of gravel are exposed on the crests of slopes, and gravel mixed with glacial till is exposed in various spots. The topography is hilly. Slopes generally are short and complex.

These soils are suitable for meadow, pasture, and woodland, but they are too steep and too droughty to be suitable for cropland. Erosion is a hazard. Very low moisture-holding capacity and low natural fertility are serious limitations. Cultivated fields should be seeded to permanent vegetation. Most of the acreage is oak forest or permanent pasture. Only a small acreage is cropland. (Capability unit VIe–2; woodland group 3)

Emmert-Hayden complex, 18 to 25 percent slopes, eroded (ErE2).—Virgin areas of this complex are uneroded and have scattered boulders and cobblestones on the surface. In cultivated areas up to two-thirds of the original surface layer is gone. Gravel is exposed on the crests of slopes, and gravel mixed with glacial till is exposed in various spots. The topography is steep. Slopes generally are short and complex.

These soils are suitable for woodland, but they are too steep and too droughty to be suitable for cropland. Very low moisture-holding capacity is the major limitation. The erosion hazard is severe. Most of the acreage is oak forest or permanent pasture. (Capability unit VIIs–1; woodland group 3)

Estherville Series

The Estherville series consists of nearly level to sloping, somewhat excessively drained soils that are underlain by sand or gravel at a depth of 12 to 24 inches. These soils developed in calcareous, gravelly outwash (fig. 7). They occur on the outwash plain in the southern and western parts of the county, mainly in the townships adjacent to the Mississippi River. Following is a representative profile of Estherville sandy loam in a cultivated area.

0 to 12 inches, black to very dark brown, friable sandy loam.
12 to 22 inches, brown to dark-brown, very friable light sandy loam; gravelly in the lowermost few inches.
22 to 34 inches, brown, loose, calcareous very coarse sand and gravel.
34 to 56 inches, light brownish-gray, loose, calcareous coarse sand.
56 to 60 inches, yellowish-brown, loose, calcareous gravel.

These soils warm up early in spring and are easy to work. Internal drainage is good. The movement of water and air is rapid. The moisture-holding capacity is low. The organic-matter content is medium, and natural fertility is moderate to low. The reaction is medium acid in the surface layer.

Estherville sandy loam, 0 to 2 percent slopes (EsA).—This soil has a surface layer slightly thicker than that in the profile described for the series. Virgin areas are uneroded. Most of the cultivated acreage is only slightly eroded, but in spots more than a third of the original surface layer has been removed.

This soil is suited to most crops commonly grown in the county. Yields are fair. Wind erosion is a hazard in cultivated areas. Low moisture-holding capacity is a serious limitation. Conserving moisture, increasing fertility, and controlling wind erosion are the main management needs. Most of the acreage is cropland, part of it is oak forest, and the rest is permanent pasture. (Capability unit IIIs–1; woodland group 2)

Estherville sandy loam, 0 to 2 percent slopes, wind eroded (EsA2).—Wind erosion has removed between one-third and two-thirds of the original surface layer from this soil, and plowing has mixed the remaining material with dark-brown material from the subsoil. Included in mapping were small areas in slight depressions that have shallow accumulations of wind-deposited surface material.

This soil is suited to most crops commonly grown in the county. Yields are fair. Wind erosion is a hazard. Low moisture-holding capacity is a serious limitation. Conserving moisture, increasing fertility, and controlling

Figure 7.—**Profile of Estherville sandy loam, 0 to 2 percent slopes, showing thick, dark-colored surface layer and underlying gravel.**

wind erosion are the main management needs. Most of the acreage is cropland. (Capability unit IIIs–1; woodland group 2)

Estherville sandy loam, 2 to 6 percent slopes (EsB).—This soil has a surface layer slightly thicker than that in the profile described for the series. Virgin areas are uneroded. Most of the cultivated acreage is only slightly eroded, but spots on the crests of slopes have lost more than a third of the original surface layer through wind erosion. In these spots the present surface layer is a mixture of the original surface layer and material from the subsoil. The topography is gently sloping or undulating. Slopes generally are short.

This soil is suited to most crops commonly grown in the county. Yields are fair. Both wind and water erosion are hazards in cultivated areas. Low moisture-holding capacity is a serious limitation. Controlling erosion, conserving moisture, and increasing fertility are the main management needs. Most of the acreage is cropland, part of it is oak forest, and the rest is permanent pasture. (Capability unit IIIe–2; woodland group 2)

Estherville sandy loam, 2 to 6 percent slopes, eroded (EsB2).—This soil is susceptible to both wind and water erosion. Erosion has removed between one-third and two-thirds of the original surface layer of this soil, and plowing has mixed the rest with material from the subsoil. In spots on the crests of slopes, most of the original surface layer is gone and the subsoil has been turned up in plowing. In small areas in the swales or slight depressions, shallow deposits of windblown surface material have accumulated. The topography is gently sloping or undulating. Slopes generally are short.

This soil is suited to most crops commonly grown in the county. Yields are fair. Both wind and water erosion are hazards. Low moisture-holding capacity is a serious limitation. Controlling erosion, conserving moisture, and increasing fertility are the main management needs. Most of the acreage is cropland. (Capability unit IIIe–2; woodland group 2)

Estherville sandy loam, 6 to 12 percent slopes (EsC).—Virgin areas of this soil are uneroded. Most of the cultivated acreage is only slightly eroded, but spots on the crests of slopes have lost more than a third of the original surface layer through erosion. In these spots some of the subsoil has been mixed with the original surface layer in plowing. The topography is sloping or rolling. Slopes generally are short.

This soil can be used for most crops commonly grown in the county, but yields are poor. Low moisture-holding capacity and low natural fertility are serious limitations. Controlling erosion, conserving moisture, and increasing fertility are the main management needs in cultivated areas. Most of the acreage is either virgin oak forest or permanent pasture. (Capability unit IVe–2; woodland group 2)

Estherville sandy loam, 6 to 12 percent slopes, eroded (EsC2).—Between one-third and two-thirds of the original surface layer of this soil has been removed by wind and water erosion. The rest has been mixed with material from the subsoil and has a very dark brownish cast. In spots on the crests of slopes, almost all of the original surface layer is gone and the subsoil has been turned up in plowing. The topography is sloping or rolling. Slopes generally are short. Some rills have formed.

This soil can be used for most of the crops commonly grown in the county, but yields are poor. Both wind and water erosion are hazards. Low moisture-holding capacity and low natural fertility are serious limitations. Nevertheless, most of the acreage is cropland. Controlling erosion, conserving moisture, and increasing fertility are the main management needs. (Capability unit IVe–2; woodland group 2)

Fairhaven Series

The Fairhaven series consists of nearly level or undulating, moderately well drained or well drained soils. These soils are underlain by sand at a depth of 24 to 36 inches. They developed in old glacial drainageways

that became blocked. The glacial melt water ponded temporarily in the blocked drainageways, and silty sediments were then deposited over the outwash sand. These soils occur on the edges of the till bumps in the sand plain near St. Cloud and Becker. Following is a representative profile of Fairhaven silt loam, light-colored variant, in a cultivated area.

0 to 8 inches, very dark gray, very friable silt loam.
8 to 11 inches, dark grayish-brown, friable silt loam.
11 to 20 inches, dark yellowish-brown, friable silt loam.
20 to 27 inches, blotchy dark yellowish-brown, yellowish-brown and light olive-brown, friable silt loam.
27 to 35 inches, blotchy light olive-brown and grayish-brown, friable silt loam.
35 to 42 inches, loose fine sand prominently mottled with light yellowish brown, pale brown, yellowish brown, and brown.
42 to 46 inches, pale-brown, loose fine sand; distinct, light yellowish-brown mottles.
46 to 54 inches, unevenly mottled dark grayish-brown and grayish-brown, loose fine sand.

The moisture-holding capacity of these soils is moderate. The movement of air and water is moderate. The organic-matter content is medium, and natural fertility is moderate. The reaction is neutral in the surface layer.

Fairhaven silt loam, light-colored variant, 0 to 2 percent slopes (FaA).—Virgin areas of this soil are uneroded. Most of the cultivated acreage is only slightly eroded, but in spots more than a third of the original surface layer has been removed. Included in mapping were small areas where the surface layer is black or very dark grayish-brown silt loam, the subsoil silty clay loam 24 to 48 inches thick, and the substratum calcareous, stratified very fine sand and silty clay loam.

This is a productive soil that is suited to all crops commonly grown in the county. A slightly less than adequate moisture-holding capacity is the major limitation. Conserving moisture, increasing fertility, supplying organic matter, preserving tilth, and controlling erosion are the main management needs. Most of the acreage is cropland. (Capability unit IIs–1; woodland group 4)

Fairhaven silt loam, light-colored variant, 2 to 6 percent slopes (FaB).—This soil has a surface layer slightly thinner than that in the profile described for the series. In most areas erosion has removed a third of the original surface layer, and in spots even more. In some small areas the slope is 6 to 12 percent. The topography is undulating to sloping. Slopes generally are short.

This is a productive soil that is suited to all crops commonly grown in the county. A slightly less than adequate moisture-holding capacity is the major limitation. The erosion hazard is slight. Conserving moisture, increasing fertility, supplying organic matter, preserving tilth, and controlling erosion are the main management needs. Most of the acreage is cropland. (Capability unit IIs–1; woodland group 4)

Hayden Series

The Hayden series consists of nearly level to steep, deep, well-drained soils. These soils developed in gray, calcareous glacial till. They occur in the northwestern and central parts of the county. Following is a representative profile of Hayden fine sandy loam in a virgin site.

0 to 4 inches, very dark grayish-brown, very friable fine sandy loam.
4 to 16 inches, dark grayish-brown, friable fine sandy loam.
16 to 41 inches, dark yellowish-brown, firm clay loam.
41 to 51 inches, light olive-brown, friable loam to clay loam that contains free lime.

The moisture-holding capacity of these soils is high. The movement of air and water is moderate. The organic-matter content is low, and natural fertility is moderate. The reaction is slightly acid.

Hayden fine sandy loam, 0 to 2 percent slopes (HaA).—Virgin areas of this soil are uneroded, and cultivated areas are only slightly eroded. In a few places where the glacial till joins the sand plain, the till is covered with a thin mantle of sandy material. Included in mapping were moderately well drained soils that have a faintly mottled subsoil, and soils that have a sandy cap less than 18 inches thick.

This soil produces good yields and is suited to all crops grown in the county. It has no serious limitations. Preserving tilth, increasing fertility, and supplying organic matter are the main management needs. Most of the acreage is cropland. The rest is woodland or permanent pasture. (Capability unit IIe–1; woodland group 6)

Hayden fine sandy loam, 2 to 6 percent slopes (HaB).—Virgin areas of this soil are uneroded. Most of the cultivated acreage is only slightly eroded, but in spots on the crests of slopes, part of the original surface layer is gone and the rest has been mixed with material from the subsoil in plowing. In a few places where the glacial till joins the sand plain, the till is covered with a thin mantle of sandy material. The topography is gently sloping or undulating. Slopes generally are short. Included in mapping were soils that have a sandy cap less than 18 inches thick.

This soil produces good yields and is suited to all crops grown in the county. There is a slight erosion hazard in cultivated areas. Controlling erosion, preserving tilth, increasing fertility, and supplying organic matter are the main management needs. Most of the acreage is cropland. The rest is woodland or permanent pasture. (Capability unit IIe–1; woodland group 6)

Hayden fine sandy loam, 2 to 6 percent slopes, moderately eroded (HaB2).—Between one-third and two-thirds of the original surface layer of this soil has been removed by erosion, and on the crests of slopes the yellowish-brown subsoil is exposed. In a few places where the glacial till joins the sand plain, the till is covered with a thin mantle of sandy material. The topography is gently sloping or undulating. Slopes generally are short. Included in mapping were soils that have a sandy cap less than 18 inches thick.

This is a productive soil that is suited to all crops grown in the county. The loss of soil through erosion has decreased the supply of organic matter, reduced fertility, and slowed down infiltration. Controlling erosion, supplying organic matter, increasing fertility, and preserving tilth are the main management needs. Most of the acreage is cropland. (Capability unit IIe–1; woodland group 6)

Hayden fine sandy loam, 6 to 12 percent slopes (HaC).—Virgin areas of this soil are uneroded. Most of the cultivated acreage is only slightly eroded, but spots on the crests of slopes have lost more than a third of their original surface layer, and the rest has been mixed with the yellowish-brown subsoil in plowing. The topography is sloping or rolling. Slopes generally are short. Included in mapping were spots where the surface layer is loamy fine sand and is less than 18 inches thick.

This is a productive soil that is suited to all crops grown in the county. Erosion is a hazard in cultivated areas. Controlling erosion, increasing fertility, supplying organic matter, and preserving tilth are the main management needs. Most of the acreage is cropland. The rest is woodland or permanent pasture. (Capability unit IIIe–1; woodland group 6)

Hayden fine sandy loam, 6 to 12 percent slopes, moderately eroded (HaC2).—Erosion has removed between one-third and two-thirds of the original surface layer from this soil, and on the crests of slopes plowing has turned up the subsoil. The topography is sloping or rolling. Slopes generally are short. Included in mapping were spots where the surface layer is loamy fine sand and is less than 18 inches thick.

This is a productive soil that is suited to all crops grown in the county, but the erosion hazard is severe. The loss of soil through erosion has decreased the supply of organic matter, reduced fertility, and slowed down infiltration. Controlling erosion, supplying organic matter, increasing fertility, and preserving tilth are the main management needs. Most of the acreage is cropland. (Capability unit IIIe–1; woodland group 6)

Hayden fine sandy loam, 6 to 12 percent slopes, severely eroded (HaC3).—Erosion has removed more than two-thirds of the original surface layer from this soil. The present surface layer is a mixture of the remaining surface material and material from the subsoil. It has a high clay content and is dark brown in color. On the crests of slopes, all of the original surface layer is gone and the yellowish-brown subsoil is exposed. Rills are common on side slopes. The topography is sloping or rolling. Slopes generally are short.

This soil is not well suited to row crops. The erosion hazard is severe. The loss of soil through erosion has decreased the supply of organic matter, reduced fertility, and slowed down infiltration. Tillage is difficult because of the high clay content of the subsoil. Nevertheless, most of the acreage is cropland. Controlling erosion, supplying organic matter, increasing fertility, and preserving tilth are the main management needs. (Capability unit IVe–1; woodland group 6)

Hayden fine sandy loam, 12 to 18 percent slopes (HaD).—The profile of this soil is shallower than the representative profile described for the series, and the surface layer is thinner than that in the representative profile. Virgin areas are uneroded, and cultivated areas are only slightly eroded. The topography is moderately steep or hilly. Slopes generally are short. Included in mapping were spots where the surface layer is loamy fine sand and is less than 18 inches thick.

This is a productive soil, but its use for row crops should be limited. If tilled, it is highly susceptible to erosion. Also, tillage is difficult, and the slope limits the use of farm machinery. Increasing fertility, supplying organic matter, and preserving tilth are the main management needs. Most of the acreage is woodland or permanent pasture. Only a small acreage is cropland. (Capability unit IVe–1; woodland group 7)

Hayden fine sandy loam, 12 to 18 percent slopes, moderately eroded (HaD2).—The profile of this soil is shallower than the representative profile described for the series, and the surface layer is thinner than that in the representative profile. Between one-third and two-thirds of the original surface layer has been removed by erosion, and on the crests of slopes the subsoil has been turned up in plowing. The present surface layer is a mixture of the remaining surface material and material from the subsoil. The topography is moderately steep or hilly. Slopes generally are short. Included in mapping were spots where the surface layer is loamy fine sand and is less than 18 inches thick.

This is a productive soil, but its use for row crops should be limited. The erosion hazard is severe. The loss of soil through erosion has slowed down infiltration. Tillage is difficult because of the high clay content of the subsoil, and the slope limits the use of farm machinery. Nevertheless, most of the acreage is cropland. Controlling erosion, increasing fertility, supplying organic matter, and preserving tilth are the main management needs. (Capability unit IVe–1; woodland group 7)

Hayden fine sandy loam, 12 to 18 percent slopes, severely eroded (HaD3).—The profile of this soil is shallower than the representative profile described for the series. More than two-thirds of the original surface layer has been removed by erosion. The present surface layer is a mixture of the remaining surface material and material from the subsoil. It is dark brown in color and has a high clay content. On the crests of slopes, all of the original surface layer is gone and the subsoil is exposed. Rills are common on side slopes. The topography is moderately steep or hilly. Slopes generally are short.

This soil is suitable for meadow, pasture, and woodland, but it is not suitable for cropland. The erosion hazard is very severe. Water erosion has removed an excessive amount of soil. Runoff is excessive, and infiltration is slow. Tillage operations are difficult because of the high clay content of the subsoil, and the slope limits the use of farm machinery. Nevertheless, most of the acreage is cropland. Controlling erosion, reducing runoff, increasing fertility, and supplying organic matter are the main management needs. Cultivated fields should be seeded to permanent vegetation. (Capability unit VIe–1; woodland group 7)

Hayden fine sandy loam, 18 to 35 percent slopes (HaE).—The profile of this soil is shallower than the representative profile described for the series, and the surface layer is thinner than that in the representative profile. Virgin areas are uneroded, and small cultivated areas have lost no more than a third of the original surface layer. The topography is steep or very steep. Slopes generally are short. Included in mapping was approximately 60 acres where between one-third and two-thirds of the original surface layer is gone.

This soil is suitable for woodland and permanent pasture but is too steep to be suitable for cropland. The erosion hazard is severe in cultivated areas. In many

places the slope is too steep to be safe for farm machinery. Most of the acreage is woodland or permanent pasture. (Capability unit VIe–1; woodland group 7)

Hubbard Series

The Hubbard series consists of deep, excessively drained or somewhat excessively drained soils that are underlain by deep sand (fig. 8). These soils developed in deeply leached, calcareous outwash. They occur mainly in the southern and western parts of the county. Following is a representative profile of Hubbard loamy sand in a cultivated area.

0 to 9 inches, black, friable loamy sand; blotches and variegations of very dark brown.
9 to 15 inches, very dark brown, friable loamy sand grading to dark brown with depth.
15 to 23 inches, dark-brown and dark yellowish-brown, very friable, loamy sand.
23 to 29 inches, dark-brown, loose sand and coarse sand.
29 to 32 inches, dark-brown, loose coarse sand and fine gravel.
32 to 60 inches, brown, loose sand.

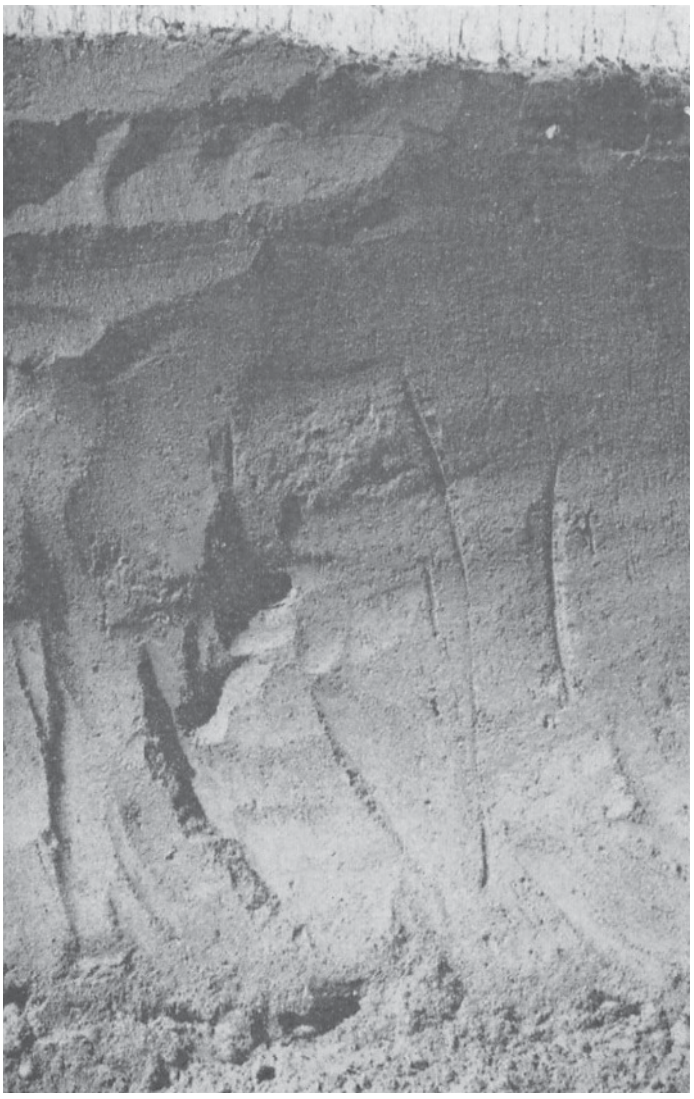

Figure 8.—**Profile of Hubbard loamy sand, 0 to 2 percent slopes.**

These soils warm up quickly in spring and are easy to work. The moisture-holding capacity is very low. The movement of air and water is rapid. The organic-matter content is low, and natural fertility is low. The reaction is medium acid in the surface layer.

Hubbard loamy sand, 0 to 2 percent slopes (HuA).—This soil has a surface layer slightly thicker than that in the profile described for the series. Virgin areas are uneroded. Most of the cultivated acreage is only slightly eroded, but in spots more than a third of the original surface layer has been removed. A few areas near the Mississippi River are dissected by the remnants of old, shallow, braided glacial drainageways.

This soil can be used for most crops commonly grown in the county, but yields are poor. Very low moisture-holding capacity and low natural fertility are the major limitations. Wind erosion is a hazard. Nevertheless, most of the acreage is cropland. The rest is oak forest or permanent pasture. Conserving moisture, increasing fertility, and controlling wind erosion are the main management needs. (Capability unit IVs–3; woodland group 1)

Hubbard loamy sand, 0 to 2 percent slopes, wind eroded (HuA2).—Wind erosion has removed between one-half and two-thirds of the original surface layer from this soil, and plowing has mixed the rest with material from the subsoil. Included in mapping were some severely eroded spots where more than two-thirds of the original surface layer is gone and the present surface layer is dark grayish brown instead of black. In slight depressions are shallow accumulations of wind-deposited surface material. Sand has drifted along fence lines and road ditches. A few areas near the Mississippi River are dissected by the remnants of old, shallow, braided drainageways.

This soil can be used for most crops commonly grown in the county, but yields are poor. Very low moisture-holding capacity and low natural fertility are the major limitations. Wind erosion and damage to seedlings by sandblasting are hazards. Nevertheless, most of the acreage is cropland. Conserving moisture, increasing fertility, and controlling wind erosion are the main management needs. (Capability unit IVs–3; woodland group 1)

Hubbard loamy sand, 2 to 6 percent slopes (HuB).—This soil has a surface layer slightly thicker than that in the profile described for the series. Virgin areas are uneroded. Most of the cultivated acreage is only slightly eroded, but in spots on the crests of slopes, more than a third of the original surface layer has been lost through wind erosion and the present surface layer is a mixture of the subsoil and the remaining surface material. The topography is gently sloping or undulating. Slopes generally are short.

This soil can be used for most crops commonly grown in the county, but yields are poor. Very low moisture-holding capacity and low natural fertility are the major limitations. Wind erosion is a hazard. Nevertheless, most of the acreage is cropland. The rest is oak forest or permanent pasture. Conserving moisture, increasing fertility, and controlling wind erosion are the main management needs. (Capability unit IVs–3; woodland group 1)

Hubbard loamy sand, 2 to 6 percent slopes, eroded (HuB2).—Wind erosion has removed between one-third and

two-thirds of the original surface layer from this soil, and plowing has mixed the remaining surface material with material from the subsoil. Included in mapping were severely eroded spots where more than two-thirds of the original surface layer is gone and the present surface layer is dark grayish brown instead of black. In slight depressions are shallow accumulations of wind-deposited surface material. Sand has drifted along fence lines and in road ditches. The topography is gently sloping or undulating. Slopes generally are short.

This soil can be used for most crops commonly grown in the county, but yields are poor. Very low moisture-holding capacity and low natural fertility are the major limitations. Wind erosion and damage to seedlings by sandblasting are hazards. Nevertheless, most of the acreage is cropland. Conserving moisture, increasing fertility, and controlling wind erosion are the main management needs. (Capability unit IVs–3; woodland group 1)

Hubbard loamy sand, 2 to 6 percent slopes, severely eroded (HuB3).—Wind erosion has removed nearly all of the original surface layer from this soil, and plowing has mixed the rest with material from the subsoil. The present surface layer is dark grayish brown instead of black. Spots in shallow depressions or swales have shallow accumulations of wind-shifted surface material. Sand has drifted along fence lines and road ditches. The topography is gently sloping or undulating. Slopes generally are short.

This soil is suitable for meadow, pasture, and woodland, but it is too severely eroded to be suitable for cropland. Yields of cultivated crops are very poor. Very low moisture-holding capacity is a serious limitation. Wind erosion and damage to seedlings by sandblasting are hazards. Nevertheless, most of the acreage is cropland. Conserving moisture, controlling erosion, and increasing fertility are the main management needs. All of the acreage should be in permanent vegetation. (Capability unit VIs–3; woodland group 1)

Hubbard loamy sand, 6 to 12 percent slopes (HuC).—Virgin areas of this soil are uneroded. Most of the cultivated acreage is only slightly eroded, but in spots on the crests of slopes, more than a third of the original surface layer is gone and plowing has mixed the rest with material from the subsoil. The topography is sloping or rolling. Slopes generally are short.

This soil is suitable for meadow, pasture, and woodland, but it is too steep and too droughty to be suitable for cropland. Very low moisture-holding capacity and low natural fertility are the major limitations. Erosion is a hazard. Some of the acreage is cropland, but most is oak forest or permanent pasture. Cultivated fields should be seeded to permanent vegetation. (Capability unit VIs–3; woodland group 1)

Hubbard loamy sand, 6 to 12 percent slopes, eroded (HuC2).—Wind and water erosion have removed between one-third and two-thirds of the original surface layer from this soil, and plowing has mixed the rest with material from the subsoil. The present surface layer is dark grayish brown instead of black. Included in mapping were spots on the crests of slopes where all of the original surface layer is gone and the subsoil is exposed. There are rills and gullies on side slopes. The topography is sloping or rolling. Slopes generally are short.

This soil is suitable for meadow, pasture, and woodland, but it is too droughty and too highly susceptible to erosion to be suitable for cropland. Yields of cultivated crops are very poor. Very low moisture-holding capacity and low natural fertility are the major limitations. The erosion hazard is severe. Nevertheless, most of the acreage is cropland. Conserving moisture, increasing fertility, and controlling erosion are the main management needs. Cultivated fields should be seeded to permanent vegetation. (Capability unit VIs–3; woodland group 1)

Hubbard loamy sand, 6 to 12 percent slopes, severely eroded (HuC3).—More than two-thirds of the original surface layer of this soil has been removed by wind and water erosion. The rest has been mixed with the subsoil in plowing, and the present surface layer is dark brown instead of black. In the most severely eroded spots, particularly on the crests of slopes, all of the original surface layer is gone and the subsoil is exposed. There are rills and gullies on side slopes. The topography is sloping or rolling. Slopes generally are short.

This soil is suitable for woodland but is too droughty and too severely eroded to be suitable for cropland. Yields of cultivated crops are very poor. Very low moisture-holding capacity and the hazard of erosion are the major limitations. Nevertheless, most of the acreage is cropland. The entire acreage should be in permanent vegetation. (Capability unit VIIs–1; woodland group 1)

Hubbard loamy sand, 12 to 25 percent slopes (HuE).—For the most part, this soil has not been cultivated, and consequently it has been little affected by erosion. It has a surface layer thinner than that in the profile described for the series. The topography is moderately steep or steep. Slopes generally are short.

This soil is suitable for woodland, but it is too steep and too droughty to be suitable for cropland. The very low moisture-holding capacity is the major limitation. The erosion hazard is severe. Most of the acreage is oak forest or permanent pasture. (Capability unit VIIs–1; woodland group 1)

Hubbard loamy sand, 12 to 25 percent slopes, eroded (HuE2).—Between one-third and two-thirds of the original surface layer has been removed from this soil by wind and water erosion, and the rest has been mixed with the subsoil in plowing. The present surface layer is dark grayish brown instead of black. In severely eroded spots, particularly on the crests of slopes, all of the original surface layer is gone and the dark-brown subsoil is exposed. There are rills and gullies on side slopes. The topography is moderately steep or steep. Slopes generally are short.

This soil is suitable for woodland but is too droughty and too steep to be suitable for cropland. Very low moisture-holding capacity is the major limitation. The erosion hazard is severe. In many places the slope is too steep to be safe for farm machinery. Nevertheless, most of the acreage is cropland. The entire acreage should be permanent vegetation. (Capability unit VIIs–1; woodland group 1)

Hubbard sandy loam, 0 to 2 percent slopes (HyA).—Virgin areas of this soil are uneroded. Most of the cultivated acreage is only slightly eroded, but in spots more

than a third of the original surface soil layer has been removed.

This soil is suited to most crops commonly grown in the county. Yields are fair. Very low moisture-holding capacity is the major limitation. Wind erosion is a hazard in cultivated fields. Conserving moisture, increasing fertility, and controlling wind erosion are the main management needs. Most of the acreage is cropland. The rest is oak forest or permanent pasture. (Capability unit IIIs–1; woodland group 1)

Hubbard sandy loam, 0 to 2 percent slopes, wind eroded (HyA2).—Between one-third and two-thirds of the original surface layer of this soil has been removed by wind erosion, and the rest has been mixed with the subsoil in plowing. In slight depressions are shallow accumulations of wind-deposited surface material.

This soil is suited to most crops commonly grown in the county. Yields are fair. Very low moisture-holding capacity is the major limitation. Wind erosion is a hazard. Conserving moisture, increasing fertility, and controlling wind erosion are the main management needs. Most of the acreage is cropland. (Capability unit IIIs–1; woodland group 1)

Hubbard sandy loam, 2 to 6 percent slopes (HyB).—Virgin areas of this soil are uneroded. Most of the cultivated acreage is only slightly eroded, but in spots on the crests of slopes, more than a third of the original surface layer is gone and the rest has been mixed with the subsoil in plowing. The topography is gently sloping or undulating. Slopes generally are short.

This soil is suited to most crops commonly grown in the county. Yields are fair. Both wind and water erosion are hazards in cultivated areas. Very low moisture-holding capacity is a serious limitation. Controlling erosion, conserving moisture, and increasing fertility are the main management needs. Most of the acreage is cropland. The rest is oak forest or permanent pasture. (Capability unit IIIe–2; woodland group 1)

Hubbard sandy loam, 2 to 6 percent slopes, eroded (HyB2).—Between one-third and two-thirds of the original surface layer of this soil has been removed by wind erosion, and the rest has been mixed with material from the subsoil. In spots on the crests of slopes, most of the original surface layer is gone and the subsoil has been turned up in plowing. In slight depressions are shallow accumulations of wind-deposited surface material. The topography is gently sloping or undulating. Slopes generally are short.

This soil is suited to most crops commonly grown in the county. Yields are fair. Both wind and water erosion are hazards. Very low moisture-holding capacity is a serious limitation. Controlling erosion, conserving moisture, and increasing fertility are the main management needs. Most of the acreage is cropland. (Capability unit IIIe–2; woodland group 1)

Hubbard sandy loam, 6 to 12 percent slopes, eroded (HyC2).—Wind and water erosion have removed between one-third and two-thirds of the original surface layer from this soil, and plowing has mixed the rest with material from the subsoil. The present surface layer has a very dark brownish cast. On the crests of slopes, much of the original surface layer is gone and subsoil has been turned up in plowing. There are a few rills on side slopes. Included in mapping was about 25 acres that is uneroded. The topography is sloping or rolling. Slopes generally are short.

This soil can be used for most crops commonly grown in the county, but yields are poor. Both wind and water erosion are hazards. Very low moisture-holding capacity and low natural fertility are serious limitations. Nevertheless, most of the acreage is cropland. Controlling erosion, conserving moisture, and increasing fertility are the main management needs. (Capability unit IVe–2; woodland group 1)

Isanti Series

The Isanti series consists of level or slightly depressional, deep, very poorly drained soils. These soils developed in loose outwash sand that had been sorted by wind and water action. They occur on broad flats, in slight depressions, and around the edges of some of the peat bogs in the central and northern parts of the county. Following is a representative profile of Isanti loamy fine sand in a virgin site.

0 to 11 inches, black, very friable, mucky loamy fine sand; high in organic-matter content.
11 to 18 inches, dark-gray, loose fine sand.
18 to 25 inches, grayish-brown, loose fine sand.
25 to 36 inches, grayish-brown, loose fine sand; many, distinct, yellowish-brown mottles.
36 to 42 inches, gray, loose sand; many, prominent, brown and dark-brown mottles.
42 to 48 inches, strongly mottled coarse sand; blotchy; distinct mottles of brown and dark brown.

Unless artificially drained, these soils are not suitable for cultivation. The movement of water and air is restricted by a high water table but would be rapid if the soils were drained. The moisture-holding capacity is low. The organic-matter content is high, and inherent fertility is low. The reaction is strongly acid in the surface layer.

Isanti loamy fine sand (Is).—In many places this soil has a thin layer of peat or muck on the surface. The slope range is 0 to 1 percent. Included in mapping were areas of very poorly drained coarse sand.

If adequately drained, this soil can be used for most crops grown in the county, but it is generally not suitable for alfalfa. Yields are poor or fair. Poor drainage and low fertility are the major limitations. Controlling excess surface water and improving internal drainage are the main management needs. Most of the acreage is undrained and supports aquatic grasses, sedges, and willows. Only a small part is drained and suitable for cropland. (Capability unit IVw–2; woodland group 11)

Lino Series

The Lino series consists of nearly level or slightly undulating, deep, somewhat poorly drained soils. These soils developed in wind- and water-sorted outwash of loose fine sand. They occur in the central and northern parts of the county. Following is a representative profile of Lino loamy fine sand in a cultivated area.

0 to 7 inches, very dark grayish-brown, loose loamy fine sand.
7 to 16 inches, dark grayish-brown, loose fine sand; many, distinct, dark-brown and dark reddish-brown mottles.

16 to 38 inches, brown, loose fine sand; many, prominent, brown and yellowish-red mottles.
38 to 48 inches, brown, loose fine sand; few, distinct, gray mottles.

These soils have good tilth and are easy to work. The movement of air and water is restricted by a high water table but would be rapid of the soils were drained. The moisture-holding capacity is low. The organic-matter content is medium, and inherent fertility is low. The reaction is strongly acid in the surface layer.

Lino loamy fine sand, 0 to 2 percent slopes (LnA).—Virgin areas of this soil are uneroded, and cultivated areas are slightly eroded. In the virgin areas, the surface layer is thinner and slightly darker colored than that in the profile described. Included in mapping were small areas where the surface layer either is covered with a thin layer of peat or contains a large amount of organic matter, and areas where the surface layer is black coarse sand.

This soil is suited to most crops commonly grown in the county, but alfalfa stands generally are short lived. Excessive wetness and low fertility are the major limitations. The main management needs are adequate drainage, measures that increase fertility, and a cropping system that adds organic matter to the soil and helps to control erosion. Drained areas are likely to be droughty during prolonged dry periods and to be susceptible to wind erosion. Much of the acreage is cropland, but a significant acreage is covered with trees and brush. (Capability unit IIIw–2; woodland group 9)

Lino loamy fine sand, 0 to 2 percent slopes, wind eroded (LnA2).—Between one-third and two-thirds of the original surface layer of this soil has been removed or shifted by wind erosion. The present surface layer is slightly darker brown than the subsoil; the change in color is generally a sharp line at the base of the plow layer. On slight rises the sand appears looser because some of the fine silt and clay particles have blown away.

This soil is suited to most crops grown in the county, but alfalfa stands usually are short lived. Excessive wetness and low fertility are the major limitations. Wind erosion is a hazard. The main management needs are adequate internal drainage, measures that increase fertility, and a cropping system that adds organic matter to the soil and helps to control erosion. Drained areas are likely to be slightly droughty during prolonged dry periods. Most of the acreage is cropland. (Capability unit IIIw–2; woodland group 9)

Lino loamy fine sand, 2 to 6 percent slopes (LnB).—Virgin areas of this soil are uneroded. Most of the cultivated acreage is only slightly eroded, but spots on the crests of slopes have lost more than a third of their original surface layer through wind erosion. The present surface layer in these spots is slightly lighter colored, and the sand somewhat looser. The topography is gently sloping or undulating. Slopes generally are short. The gradient is dominantly 3 percent.

This soil is suited to most crops commonly grown in the county. Excessive wetness and low fertility are the major limitations. The main management needs are adequate drainage, measures that increase fertility, and a cropping system that adds organic matter to the soil and helps to control erosion. Drained areas are likely to be slightly droughty during prolonged dry periods and to be susceptible to wind erosion. Much of the acreage is cropland, but a significant acreage is covered with trees and brush. (Capability unit IIIw–2; woodland group 9)

Lino loamy fine sand, loamy substratum, 0 to 2 percent slopes (LsA).—This soil has a black surface layer. Virgin areas are uneroded, and cultivated areas are slightly eroded. Included in mapping were areas where the surface layer is very dark grayish brown.

This soil is suited to most crops grown in the county, but alfalfa stands are short lived. Excessive wetness and low fertility are the major limitations. The main management needs are adequate internal drainage, measures that increase fertility, and a cropping system that adds organic matter to the soil and helps to prevent wind erosion. Drained areas are likely to be susceptible to wind erosion. Much of the acreage is cropland, but a significant acreage is covered with trees and brush. (Capability unit IIIw–2; woodland group 9)

Loamy Wet Land

Loamy wet land (lw) consists of dark-colored, poorly drained or very poorly drained soil material. It occurs as depressions and nearly level areas. The slope range is 0 to 2 percent. The surface layer ranges from loam to silty clay loam in texture. In places it is capped with a thin layer of peat. The material is moderately deep or deep over gray till, red till, a mixture of red and gray till, lacustrine silt, or outwash, depending on location.

The moisture-holding capacity of this land type varies but for the most part is moderate to high. The movement of air and water is moderate or moderately slow; it is restricted by a high water table. The organic-matter content is high, and natural fertility is moderate. The reaction is acid to alkaline.

If adequately drained, much of this land type is suited to most crops grown in the county. Some areas are not suitable for alfalfa, and in others alfalfa is likely to be short lived. The soil material is likely to compact if worked when wet. Wetness is the major limitation. Controlling excess surface water, improving internal drainage, supplying organic matter, and preserving tilth are the main management needs. Much of the acreage is undrained and supports aquatic grasses, sedges, and willows. The drained areas are cropland or pasture. (Capability unit IVw–1; woodland group 11)

Marsh

Marsh (Ma) consists of areas that are covered with water most of the year. The slope range is 0 to 1 percent. The vegetation consists of aquatic grasses, sedges, and cattails. (Capability unit VIIIw–1; woodland group 11)

Milaca Series

The Milaca series consists of deep, nearly level to steep, well-drained soils. These soils developed in noncalcareous, red glacial till. They occur on ground moraines, mainly in the northern part of the county in

Santiago and Blue Hill Townships. They also occur north of Becker and in the rough morainic area northeast of Elk River. Following is a representative profile of Milaca fine sandy loam in a cultivated area.

0 to 7 inches, very dark grayish-brown, friable fine sandy loam.
7 to 19 inches, brown, friable fine sandy loam; many stones and cobblestones.
19 to 52 inches, dark reddish-brown, firm, heavy sandy loam.
52 to 124 inches, reddish-brown, firm, heavy sandy loam.

The movement of air and water is good through the upper part of these soils but is restricted in the subsoil by a fragipan. The fragipan, which begins at a depth of about 19 inches, also limits the root zone. The moisture-holding capacity is moderate. The organic-matter content is low, and natural fertility is moderate. The reaction is medium acid in the surface layer.

Milaca fine sandy loam, 0 to 2 percent slopes (MfA).—Virgin areas of this soil are uneroded, and cultivated areas are only slightly eroded. Included in mapping were spots where the surface layer is loamy fine sand in texture and is less than 18 inches thick.

This is a productive soil that is suited to all crops grown in the county. It has no serious limitations. The erosion hazard is only slight. Increasing fertility and supplying organic matter are the main management needs. Most of the acreage is cropland. The rest is woodland or permanent pasture. (Capability unit IIe–1; woodland group 6)

Milaca fine sandy loam, 2 to 6 percent slopes (MfB).—Virgin areas of this soil are uneroded. Most of the cultivated acreage is only slightly eroded, but in spots on the crests of slopes the brown subsoil has been mixed with the surface layer in plowing. Some spots are capped with sand. The topography is gently sloping or undulating. Slopes generally are short.

This is a productive soil that is suited to all crops grown in the county. There is a slight to moderate erosion hazard in cultivated areas. Controlling erosion, increasing fertility, and supplying organic matter are the main management needs. Most of the acreage is cropland. The rest is woodland or permanent pasture. (Capability unit IIe–1; woodland group 6)

Milaca fine sandy loam, 2 to 6 percent slopes, moderately eroded (MfB2).—Between one-third and two-thirds of the original surface layer of this soil has been removed by erosion. On the crests of slopes, much of the original surface layer is gone and the reddish-brown subsoil has been turned up in plowing. Cobblestones generally are exposed on eroded slopes. Included in mapping was about 60 acres where the surface layer is loamy fine sand and is 24 to 42 inches thick over reddish-brown sandy loam till.

This is a productive soil that is suited to all crops grown in the county. The loss of soil through erosion has decreased the supply of organic matter, reduced fertility, and slowed down infiltration. Controlling erosion, increasing fertility, and supplying organic matter are the main management needs. Most of the acreage is cropland. (Capability unit IIe–1; woodland group 6)

Milaca fine sandy loam, 6 to 12 percent slopes, eroded (MfC2).—Between one-third and two-thirds of the original surface layer of this soil has been removed by erosion. On the crests of slopes, much of the original surface layer is gone and the subsoil has been turned up in plowing. There are cobblestones on these eroded spots. Included in mapping were areas where the slope is more than 12 percent. Also included was about 40 acres where erosion is only slight, approximately 65 acres where it is severe, and about 20 acres where the surface layer is loamy fine sand and is 24 to 42 inches thick over reddish-brown sandy loam till. The topography is sloping or rolling. Slopes generally are short.

This is a productive soil that is suited to all crops grown in the county, but the erosion hazard is severe. The loss of soil through erosion has decreased the supply of organic matter, reduced fertility, and slowed down infiltration. Nevertheless, most of the acreage is cropland. Controlling erosion, increasing fertility, supplying organic matter, and preserving tilth are the main management needs. (Capability unit IIIe–1; woodland group 6)

Milaca fine sandy loam, 12 to 18 percent slopes (MfD).—In virgin areas this soil has a surface layer thinner and darker colored than that in the profile described for the series. Virgin areas are uneroded, and cultivated areas are only slightly eroded. Included in mapping were spots both steeper and less steep, about 25 acres where between one-third and two-thirds of the original surface layer is gone, and about 30 acres where the surface layer is loamy fine sand and is 24 to 42 inches thick. The topography is moderately steep or hilly. Slopes generally are short.

This is a productive soil, but its use for row crops should be limited. Erosion is a hazard in cultivated areas. Tillage operations are difficult, and the slope limits the use of farm machinery. Controlling water erosion, increasing fertility, and supplying organic matter are the main management needs. The acreage is small. Most of it is woodland or permanent pasture. Only a small acreage is cropland. (Capability unit IVe–1; woodland group 7)

Milaca fine sandy loam, 18 to 25 percent slopes (MfE).—In virgin areas this soil has a surface layer thinner and darker colored than that in the profile described for the series. Virgin areas are uneroded, and cultivated areas have lost no more than a third of the original surface layer. Included in mapping was about 25 acres where erosion has removed between one-third and two-thirds of the original surface layer. The topography is steep. Slopes generally are short.

This soil is suited to woodland or permanent pasture. The loss of soil through water erosion, the excessive runoff, the reduced infiltration, and the hazard of operating farm machinery make this soil unsuitable for cropland. The acreage is small. Most of it is woodland or native pasture, but spots that occur within less sloping areas of Milaca fine sandy loam have been cleared and cultivated. (Capability unit VIe–1; woodland group 7)

Mora Series

The Mora series consists of deep, nearly level or gently sloping, moderately well drained soils. These soils developed in noncalcareous, red glacial till. They occur in the northern part of the county, mainly in Santiago and

Blue Hill Townships. Following is a representative profile of Mora loam in a cultivated area.

0 to 5 inches, very dark gray to very dark brown, friable loam.
5 to 16 inches, dark grayish-brown, friable sandy loam; faint, dark-gray and grayish-brown mottles.
16 to 20 inches, brown, firm loam; faint, yellowish-brown mottles.
20 to 30 inches, reddish-brown, firm, heavy sandy loam; many, distinct, reddish-brown and yellowish-red mottles.
30 to 42 inches, reddish-brown, firm sandy loam; many, prominent, reddish-brown, yellowish-red, and dark reddish-brown mottles.

The movement of air and water is good through the upper part of these soils but is restricted in the subsoil by a fragipan. The fragipan, which begins at a depth of about 20 inches, also limits the root zone. The moisture-holding capacity is moderate. The organic-matter content is low, and natural fertility is moderate. The reaction is strongly acid in the surface layer.

Mora loam, 0 to 2 percent slopes (MoA).—In virgin areas this soil has a surface layer thinner and slightly darker colored than that in the profile described for the series. Virgin areas are uneroded, and cultivated areas are only slightly eroded. Included in mapping were a few spots where the surface layer is loamy fine sand and is less than 18 inches thick. Also included were sandy spots.

This soil is suitable for most crops grown in the county but is unsuitable for alfalfa unless limed and fertilized. Internal drainage is somewhat restricted, and the subsoil is likely to be saturated for a short time in spring. The soil is likely to compact if worked when wet. The erosion hazard is only slight. Increasing fertility, supplying organic matter, and preserving tilth are the main management needs. Most of the acreage is cropland. The rest is woodland or permanent pasture. (Capability unit IIe–1; woodland group 6)

Mora loam, 2 to 6 percent slopes (MoB).—In virgin areas this soil has a surface layer thinner and slightly darker colored than that in the profile described for the series. Virgin areas are uneroded, and cultivated areas are only slightly eroded. Included in mapping were spots where the surface layer is loamy sand and is less than 18 inches thick. The topography is gently sloping or undulating. The slope is dominantly 3 percent. Slopes generally are short.

This soil is suitable for most crops grown in the county but is unsuitable for alfalfa unless limed and fertilized. Internal drainage is somewhat restricted, and the subsoil is likely to be saturated for a short time in spring. Also, there is a slight to moderate erosion hazard. Controlling erosion, increasing fertility, supplying organic matter, and preserving tilth are the main management needs. Most of the acreage is cropland. The rest is woodland or permanent pasture. (Capability unit IIe–1; woodland group 6)

Peat and Muck

Peat and muck are very poorly drained organic soils that are wet much of the year. Peat consists mainly of partly decomposed plant remains. Muck has undergone more decomposition than peat and contains a higher percentage of silt and clay. These soils have a high water table. They occupy low-lying flats, wet depressions, former lakes and ponds, and flood plains. They occur in all parts of the county, but the largest acreage is in the central part.

The moisture-holding capacity of these soils is very high. The organic-matter content is very high. The supply of available phosphorus and potash is very low. The reaction generally is slightly acid.

Peat and muck, deep (Pa).—These soils are more than 42 inches thick. They occur in bogs and along streams and are frequently flooded.

If adequately drained, these soils are suitable for cropland and vegetable gardens. Wetness, low fertility, and the hazard of summer frost are the major limitations. Wind erosion is likely to be a hazard in cultivated areas. Controlling excess surface water, improving internal drainage, controlling wind erosion, and supplying fresh organic matter are the main management needs. Adequate controls are needed to keep drained areas from becoming too dry. Most of the acreage is undrained and supports aquatic grasses and sedges. Part of the undrained acreage is native pasture. Only a small acreage is drained and cropped. (Capability unit IIIw–3; woodland group 10)

Peat and muck, shallow, over loam (Pc).—These soils are 12 to 42 inches thick. They occur in slight depressions within or adjacent to the till areas in the county.

If adequately drained, these soils are suitable for cropland or vegetable gardens. Wetness, low fertility, and the hazard of summer frost are the major limitations. Wind erosion is likely to be a hazard in cultivated areas. Controlling excess surface water, improving internal drainage, controlling wind erosion, and supplying fresh organic matter are the main management needs. Most of the acreage is undrained and supports aquatic grasses and sedges. Part of the undrained acreage is native pasture. Only a small acreage is drained and cropped. (Capability unit IIIw–3; woodland group 10)

Peat and muck, shallow, over sand (Pd).—These soils are 12 to 42 inches thick. They occur in depressions in sandy areas, and also along streams that have low banks and overflow frequently.

If adequately drained, these soils are suitable for cropland or vegetable gardens. Wetness, low fertility, shallowness over sand, and the hazard of late-summer frost are the major limitations. Wind erosion is likely to be a hazard in cultivated areas. Controlling excess surface water, improving internal drainage, supplying fresh organic matter, and controlling wind erosion are the main management needs. Stabilizing and maintaining ditchbanks are problems. Most of the acreage is undrained and supports aquatic grasses and sedges. Part of the undrained acreage is native pasture. Only a small acreage is drained and cropped. (Capability unit IVw–3; woodland group 10)

Peat-Lino complex (Pn).—This complex consists of broad areas of peat and many small islands of sandy soils that are deep, dark-colored, and poorly drained or very poorly drained. It occurs mainly in the broad, level areas along the St. Francis River and is frequently flooded. Peat makes up 50 percent or more of the complex. Ordinarily, the peat is shallow over sand. The islands of sandy soils range from half an acre to 5 acres

in size. For a description of these soils, refer to "Lino Series."

The movement of air and water is ordinarily restricted by a high water table but would be moderate to rapid if the soils were drained. The organic-matter content is high, and natural fertility is low. The reaction is medium acid. The moisture-holding capacity of peat is high, and that of the sandy soils is low.

If this complex were drained, it would be suited to most crops grown in the county, except alfalfa. Wetness, the hazard of flooding, and low fertility are the major limitations. Controlling excess surface water and improving internal drainage are the main management needs. Most of the acreage is undrained. The vegetation consists mainly of marsh grasses, cattails, and sedges. Some of the sandy islands support trees and brush. If the soils dry out enough that farm machinery can be used, the marsh grasses are cut for hay. (Capability unit IVw–2; woodland group 11)

Pomroy Series

The Pomroy series consists of nearly level or undulating, well drained or moderately well drained soils. These soils are underlain by noncalcareous, red glacial till at a depth of 24 to 42 inches. They occur in the northern part of the county near Santiago, and also as scattered areas along the Benton County line. Following is a representative profile of Pomroy loamy fine sand in a cultivated area.

0 to 8 inches, very dark grayish-brown, loose loamy fine sand.
8 to 12 inches, dark-brown, very dark grayish-brown, and dark grayish-brown, loose loamy sand.
12 to 28 inches, dark grayish-brown and dark-brown, loose loamy sand; faint, brown mottles.
28 to 34 inches, mottled loose loamy sand; mottles are brown and dark brown.
34 to 48 inches, reddish-brown, firm fine sandy loam; many, prominent, reddish-brown, dark reddish-brown, reddish-gray, and yellowish-red mottles.

The movement of air and water is rapid in the upper part of these soils but is moderately slow in the subsoil, particularly in spring, because of a fragipan. The pan, which begins at a depth of about 34 inches, also limits the root zone. The moisture-holding capacity is low. The organic-matter content is low, and natural fertility is low. The reaction is strongly acid in the surface layer.

Pomroy loamy fine sand, 0 to 2 percent slopes (PoA).—Virgin areas of this soil are uneroded, and cultivated areas are only slightly eroded. Included in mapping were spots where the surface layer is sandy and is less than 24 inches or more than 42 inches thick.

This soil is suited to most crops commonly grown in the county. Yields are fair. Low moisture-holding capacity and low natural fertility are the major limitations. Wind erosion is a hazard in cultivated areas. Conserving moisture, increasing fertility, and controlling wind erosion are the main management needs. Most of the acreage is cropland. The rest is oak forest or permanent pasture. (Capability unit IIIs–2; woodland group 5)

Pomroy loamy fine sand, 2 to 6 percent slopes (PoB).—Virgin areas of this soil are uneroded, and cultivated areas are only slightly eroded. Included in mapping were spots where the surface layer is sandy and is less than 24 inches or more than 42 inches thick. The topography is gently sloping or undulating. Slopes generally are short.

This soil is suited to most crops commonly grown in the county. Yields are fair. Low moisture-holding capacity and low natural fertility are the major limitations. Wind erosion is a hazard in cultivated areas. Conserving moisture, increasing fertility, and controlling wind erosion are the main management needs. Most of the acreage is cropland. The rest is oak forest or permanent pasture. (Capability unit IIIs–2; woodland group 5)

Ronneby Series

The Ronneby series consists of deep, somewhat poorly drained soils. These soils developed in noncalcareous, red glacial till that contains cobblestones. They occur in nearly level areas and on the gentle lower slopes of ground moraines. The largest acreage is in the northern part of the county, mainly in Santiago and Blue Hill Townships. Following is a representative profile of Ronneby loam in a virgin site.

0 to 3 inches, black loam.
3 to 8 inches, dark-gray, friable sandy loam; many, fine, distinct mottles.
8 to 16 inches, grayish-brown, friable sandy loam; many, medium, prominent, dark-colored mottles.
16 to 30 inches, dark-brown, firm fine sandy loam; many, medium, distinct, reddish-gray mottles.
30 to 42 inches, firm sandy loam; many cobblestones; prominent mottles of dark brown, reddish brown, dark reddish brown, and reddish gray.

The moisture-holding capacity of these soils is moderate. The movement of air and water is somewhat restricted, particularly in spring, by a fragipan. The pan begins at a depth of about 16 inches. The organic-matter content is medium, and natural fertility is moderate. The reaction is medium acid.

Ronneby loam (Ro).—In cultivated areas the surface layer of this soil is very dark grayish brown. In a few places where the glacial till adjoins the sand plain, there is a mantle of sandy material over the till. Included in mapping were small areas of a soil that developed in the sandy material. The slope range is 0 to 2 percent.

This soil is suitable for most crops grown in the county but is unsuitable for alfalfa unless limed and fertilized. Also, it is likely to be wet in spring. Internal drainage is somewhat restricted, and the subsoil is likely to be saturated. Controlling erosion, increasing fertility, supplying organic matter, and preserving tilth are the main management needs. Most of the acreage is cropland. The rest is woodland or permanent pasture. (Capability unit IIw–1; woodland group 8)

Salida Series

The Salida series consists of nearly level to hilly, excessively drained soils that are underlain by calcareous sand and gravel at a depth of 24 to 36 inches. These soils developed in calcareous gravelly outwash. They occur on the outwash plain in the southern and western parts of the county, mainly in the townships adjacent to

the Mississippi River. Following is a representative profile of Salida loamy sand in a cultivated area.

0 to 6 inches, black, very friable loamy sand.
6 to 10 inches, very dark grayish-brown, very friable loamy sand.
10 to 16 inches, dark-brown, loose gravelly loamy sand and gravel.
16 to 30 inches, dark-brown, loose sand and coarse sand.
30 to 39 inches, dark grayish-brown to brown, loose, calcareous gravel.
39 to 43 inches, grayish-brown to pale-brown, loose, calcareous sand.
43 to 54 inches, grayish-brown to pale-brown, loose, calcareous sand and gravel.

These soils warm up early in spring and are easy to work. The moisture-holding capacity is very low. The movement of air and water is very rapid. The organic-matter content is low, and natural fertility is low. The reaction is medium acid in the surface layer.

Salida complex, 0 to 6 percent slopes (SaB).—The soils in this complex have a surface layer thicker than that in the profile described for the series. Virgin areas are uneroded. Most of the cultivated acreage is only slightly eroded, but in spots more than a third of the original surface layer has been removed. In most areas the underlying gravel is calcareous, but in places the soils have been deeply leached. The topography is nearly level or undulating. Slopes generally are short.

These soils can be used for most crops grown in the county, but yields are poor. Very low moisture-holding capacity and low natural fertility are the major limitations. Wind erosion is a hazard. Nevertheless, most of the acreage is cropland. The rest is oak forest or permanent pasture. Conserving moisture, increasing fertility, and controlling erosion are the main management needs. (Capability unit IVs–1; woodland group 3)

Salida complex, 0 to 6 percent slopes, eroded (SaB2).—Between one-third and two-thirds of the original surface layer of these soils has been removed by wind erosion, and some of the subsoil has been mixed with the remaining surface material in plowing. Included in mapping were severely eroded spots where more than two-thirds of the original surface layer has been lost and the present surface layer is dark grayish brown instead of black. Also included were spots in slight depressions where there are shallow accumulations of wind-shifted surface material. The topography is nearly level or undulating. Slopes generally are short.

The soils in this complex can be used for most crops commonly grown in the county, but yields are poor. Very low moisture-holding capacity and low natural fertility are the major limitations. Wind erosion and damage to seedlings by sandblasting are hazards. Nevertheless, most of the acreage is cropland. Conserving moisture, increasing fertility, and controlling erosion are the main management needs. (Capability unit IVs–1; woodland group 3)

Salida complex, 6 to 12 percent slopes (SaC).—Virgin areas of these soils are uneroded. Most of the cultivated acreage is only slightly eroded, but in spots on the crests of slopes, more than half of the original surface layer has been removed and the rest has been mixed with the subsoil in plowing. The topography is sloping or rolling. Slopes generally are short.

These soils are suitable for meadow, pasture, and woodland, but are limited for use as cropland because they are too steep and too droughty. Very low moisture-holding capacity and low natural fertility are the major limitations. Erosion is a hazard. Cultivated fields should be seeded to permanent vegetation. Most of the acreage is oak forest or permanent pasture. The rest is cropland. (Capability unit IVs–1; woodland group 3)

Salida complex, 6 to 12 percent slopes, eroded (SaC2).—Wind and water erosion have removed between one-third and two-thirds of the original surface layer from these soils, and plowing has mixed the rest with material from the subsoil. The present surface layer is dark grayish brown instead of black. Included in mapping were spots on the crests of slopes where all of the original surface layer has been removed and the subsoil is exposed. There are a few rills and gullies on side slopes. The topography is sloping or rolling. Slopes generally are short.

These soils are suitable for meadow, pasture, and woodland, but are limited for use as cropland because they are too droughty and too highly susceptible to erosion. Yields of cultivated crops are very poor. Very low moisture-holding capacity and low natural fertility are the major limitations. Nevertheless, most of the acreage is cropland. Conserving moisture, increasing fertility, and controlling erosion are the main management needs. Cultivated fields should be seeded to permanent vegetation. (Capability unit IVs–1; woodland group 3)

Salida complex, 12 to 25 percent slopes (SaE).—The profile of these soils is shallower than the representative profile described for the series, and the surface layer is thinner than that in the representative profile. Virgin areas are uneroded, but cultivated areas have lost much of their original surface layer through wind and water erosion. In eroded spots, particularly on the crests of slopes, most of the original surface layer has been removed and the subsoil is exposed. The topography is moderately steep or steep. Slopes generally are short.

These soils are suitable for woodland but are too steep and too droughty to be suitable for cropland or pasture. At best, yields of pasture grasses are poor. The very low moisture-holding capacity is the major limitation. The erosion hazard is severe. Most of the acreage is oak forest or permanent pasture. The rest is cropland. (Capability unit VIIs–1; woodland group 3)

Wadena Series

The Wadena series consists of nearly level, well-drained soils that are underlain by calcareous gravel and sand at a depth of 24 to 36 inches. These soils developed in calcareous gravelly outwash. They occur on the outwash plain in the southern and western parts of the county, mainly in the townships adjacent to the Mississippi River. Following is a representative profile of Wadena loam in a cultivated area.

0 to 9 inches, black, friable loam.
9 to 15 inches, dark-brown, friable, light clay loam.
15 to 24 inches, dark-brown, friable, light clay loam.
24 to 31 inches, brown, loose gravel and sand.
31 to 42 inches, yellowish-brown, loose, calcareous gravel and sand.

The movement of air and water is moderate through the upper part of these soils but is very rapid through the subsoil. The moisture-holding capacity is moderate. The organic-matter content is high, and natural fertility is moderate. The reaction is medium acid in the surface layer.

Wadena loam, 0 to 2 percent slopes (WaA).—Virgin areas of this soil are uneroded. Most of the cultivated acreage is only slightly eroded, but in spots more than a third of the original surface layer has been removed. Included in mapping were spots where the subsoil is slightly finer textured than that in the profile described for the series.

This productive soil is suited to all crops commonly grown in the county. A slightly less than adequate moisture-holding capacity is the major limitation. There is a slight erosion hazard. Conserving moisture, increasing fertility, supplying organic matter, preserving tilth, and controlling erosion are the main management needs. Most of the acreage is cropland. The rest is permanent pasture. (Capability unit IIs–1; woodland group 4)

Zimmerman Series

The Zimmerman series consists of deep, nearly level to steep, excessively drained soils. These soils developed in loose, fine outwash sands that had been sorted by wind and water action. They occur in the central and northern parts of the county. Following is a representative profile (fig. 9) of Zimmerman loamy fine sand in a virgin site.

Figure 9.—**Profile of Zimmerman loamy fine sand.**

0 to 3 inches, very dark grayish-brown, very friable to loose loamy fine sand.
3 to 16 inches, dark yellowish-brown, loose fine sand.
16 to 30 inches, brown, loose fine sand.
30 to 48 inches, brown to yellowish-brown, loose fine sand.
48 to 64 inches, light yellowish-brown, loose fine sand.

The moisture-holding capacity of these soils is very low. The movement of air and water is rapid. The organic-matter content is low, and natural fertility is very low. The reaction is strongly acid in the surface layer.

Zimmerman loamy fine sand, 0 to 2 percent slopes (ZmA).—Virgin areas of this soil are uneroded, and cultivated areas are only slightly eroded. Included in mapping were spots where the soil is faintly mottled below a depth of 36 inches.

Most of the common crops can be grown on this soil, but yields are poor. Very low moisture-holding capacity and low natural fertility are the major limitations. Wind erosion is a hazard. Nevertheless, much of the acreage is cropland (fig. 10). The rest is oak forest or permanent pasture. Conserving moisture, increasing fertility, and controlling wind erosion are the main management needs. (Capability unit IVs–3; woodland group 1)

Figure 10.—**Rolling terrain. The soil is Zimmerman loamy fine sand, 0 to 2 percent slopes.**

Zimmerman loamy fine sand, 0 to 2 percent slopes, wind eroded (ZmA2).—Between one-third and two-thirds of the original surface layer of this soil has been removed or shifted by wind erosion. The present surface layer is slightly browner than the subsoil; the change in color is ordinarily at a sharp line at the base of the plow layer. On slight rises the sand appears looser, because some of the fine silt and clay particles have blown away. There are some drifts of sand and a few blowouts. Included in mapping were spots where the soil is faintly mottled below a depth of 36 inches.

This soil can be used for most crops commonly grown in the county, but yields are poor. Very low moisture-holding capacity and low natural fertility are the major limitations. Wind erosion and damage to seedlings by sandblasting are hazards. Nevertheless, most of the acreage is cropland. Conserving moisture, increasing

fertility, and controlling wind erosion are the main management needs. (Capability unit IVs–3; woodland group 1)

Zimmerman loamy fine sand, 2 to 6 percent slopes (ZmB).—Virgin areas of this soil are uneroded, and cultivated areas are only slightly eroded. Included in mapping were spots where there are slight accumulations of wind-shifted sand. The topography is gently sloping or undulating. Slopes generally are short.

This soil can be used for most crops commonly grown in the county, but yields are poor. Very low moisture-holding capacity and low natural fertility are the major limitations. Wind erosion is a hazard. Conserving moisture, increasing fertility, and controlling wind erosion are the main management needs. Most of the acreage is oak forest or permanent pasture. The rest is cropland. (Capability unit IVs–3; woodland group 1)

Zimmerman loamy fine sand, 2 to 6 percent slopes, eroded (ZmB2).—Between one-third and two-thirds of the original surface layer of this soil has been removed or shifted by wind erosion. The present surface layer is slightly browner than the subsoil; the change in color is ordinarily at a sharp line at the base of the plow layer. In spots on slight rises or on the crests of slopes, the present surface layer is lighter colored and the sand is looser because some of the fine silt and clay particles have blown away. Drifts of sand are common, particularly along fence lines and road ditches. There are a few blowouts, mainly near the Sand Dunes State Forest. The topography is gently sloping or undulating. Slopes generally are short.

This soil can be used for most crops commonly grown in the county, but yields are poor. Very low moisture-holding capacity and low natural fertility are the major limitations. Wind erosion and damage to seedlings by sandblasting are hazards. Nevertheless, most of the acreage is cropland. Conserving moisture, increasing fertility, and controlling wind erosion are the main management needs. (Capability unit IVs–3; woodland group 1)

Zimmerman loamy fine sand, 6 to 12 percent slopes (ZmC).—Virgin areas of this soil are uneroded. Most of the cultivated acreage is only slightly eroded, but in spots on the crests of slopes, more than a third of the original surface layer has been removed. In these eroded spots the sand is looser and the material is generally lighter colored. There are a few blowouts, mainly near the Sand Dunes State Forest. The topography is sloping or rolling. Slopes generally are short.

This soil is suitable for meadow, pasture, or woodland, but it is too droughty and too steep to be suitable for cropland. Very low moisture-holding capacity and low fertility are the major limitations. Wind erosion is a hazard. Cultivated fields should be seeded to permanent vegetation. Most of the acreage is oak forest or permanent pasture. The rest is cropland. (Capability unit VIs–3; woodland group 1)

Zimmerman loamy fine sand, 6 to 12 percent slopes, eroded (ZmC2).—Wind erosion has removed or shifted between one-third and two-thirds of the original surface layer of this soil. The present surface layer is slightly browner than the subsoil; the change in color is generally a sharp line at the base of the plow layer. The crests of slopes have lost most of the original surface layer, and some are very sandy. Blowouts are common (fig. 11), particularly near the Sand Dunes State Forest. Drifts of sand are common also. Rills have been cut on the steeper slopes. The topography is sloping or rolling. Slopes generally are short.

Figure 11.—**Blowouts in Zimmerman loamy fine sand, 6 to 12 percent slopes, eroded, have been stabilized by pine trees.**

This soil is suitable for meadow, pasture, or woodland, but it is too droughty and too erodible to be suitable for cropland. Yields of cultivated crops are very poor. Nevertheless, most of the acreage is cropland. Very low moisture-holding capacity and low natural fertility are the major limitations. Conserving moisture, increasing fertility, and controlling erosion are the main management needs. Cultivated fields should be seeded to permanent vegetation. (Capability unit VIs–3; woodland group 1)

Zimmerman fine sand, 12 to 25 percent slopes (ZfE).—Virgin areas of this soil are uneroded, but cultivated areas have lost as much as two-thirds of their original surface layer through erosion. Most of the original surface layer is gone from the crests of slopes, and loose sand is exposed. A few rills have been cut on side slopes. Blowouts and dunes are common near the Sand Dunes State Forest. The topography is moderately steep or steep. Slopes generally are short.

This soil is suitable for woodland but is too steep and too droughty to be suitable for cropland. Very low moisture-holding capacity is the major limitation. The erosion hazard is severe. About half the acreage is oak forest or permanent pasture. The rest is cropland. (Capability unit VIIs–1; woodland group 1)

Use and Management of the Soils For Crops and Pasture

The capability classification used by the Soil Conservation Service is explained in this section, and the soils of Sherburne County are grouped according to their suitability for crops. Estimated yields of specified crops are given for all the soils, and the management required for such yields is described.

Capability Groups of Soils

Capability classification is the grouping of soils to show, in a general way, their suitability for most kinds of farming. It is a practical classification based on limitations of the soils, the risk of damage when they are used, and the way they respond to treatment. The soils are classified according to degree and kind of permanent limitation, but without consideration of major and generally expensive land-forming that would change the slope, depth, or other characteristics of the soils; and without consideration of possible but unlikely major reclamation projects.

In the capability system, all kinds of soils are grouped at three levels: the capability class, the subclass, and the unit. These are discussed in the following paragraphs.

Capability Classes, the broadest groups, are designated by Roman numerals I through VIII. The numerals indicate progressively greater limitations and narrower choices for practical use, defined as follows:

Class I. Soils have few limitations that restrict their use.

Class II. Soils have moderate limitations that reduce the choice of plants or require moderate conservation practices.

Class III. Soils have severe limitations that reduce the choice of plants, require special conservation practices, or both.

Class IV. Soils have very severe limitations that restrict the choice of plants, require very careful management, or both.

Class V. Soils are subject to little or no erosion but have other limitations, impractical to remove, that limit their use largely to pasture or range, woodland, or wildlife food and cover.

Class VI. Soils have severe limitations that make them generally unsuited to cultivation and limit their use largely to pasture or range, woodland, or wildlife food and cover.

Class VII. Soils have very severe limitations that make them unsuited to cultivation and that restrict their use largely to pasture or range, woodland, or wildlife food and cover.

Class VIII. Soils and landforms have limitations that preclude their use for commercial plant production and restrict their use to recreation, wildlife, water supply, or esthetic purposes.

Capability Subclasses are soil groups within one class; they are designated by adding a small letter, *e*, *w*, *s*, or *c*, to the class numeral, for example, IIe. The letter *e* shows that the main limitation is risk of erosion unless close-growing plant cover is maintained; *w* shows that water in or on the soil interferes with plant growth or cultivation (in some soils the wetness can be partly corrected by artificial drainage); *s* shows that the soil is limited mainly because it is shallow, droughty, or stony; and *c*, used in only some parts of the United States, shows that the chief limitation is climate that is too cold or too dry.

In class I there are no subclasses, because the soils of this class have few limitations. Class V can contain, at the most, only subclasses indicated by *w*, *s*, and *c*, because the soils in it are subject to little or no erosion, though they have other limitations that restrict their use largely to pasture or range, woodland, wildlife, or recreation.

Capability Units are soil groups within the subclasses. The soils in one capability unit are enough alike to be suited to the same crops and pasture plants, to require similar management, and to have similar productivity and other responses to management. Thus, the capability unit is a convenient grouping for making many statements about management of soils. Capability units are generally designated by adding Arabic numerals to the subclass symbol, for example, IIe–1 or IIIe–2. Thus, in one symbol, the Roman numeral designates the capability class, or degree of limitation; the small letter indicates the subclass, or kind of limitation, as defined in the foregoing paragraph; and the Arabic numeral specifically identifies the capability unit within each subclass.

In the following pages each of the capability units in Sherburne County is described, and suggestions for use and management are given. To find the capability classification for any given soil, refer to the "Guide to Mapping Units."

Capability unit IIe–1

This unit consists of deep, nearly level or gently sloping loams and fine sandy loams on uplands. These soils are of the Hayden, Milaca, and Mora series. Fertility is moderate. The organic-matter content is low. Permeability is moderate, and the moisture-holding capacity is moderate to high. Hayden and Milaca soils are well drained, and Mora soils are moderately well drained. The erosion hazard is slight or moderate. The moderately eroded soils have lost between one-third and two-thirds of their original surface layer.

If well managed, the soils in this unit are highly productive. They are well suited to all crops commonly grown in the county, including corn, soybeans, small grain, alfalfa, and other hay crops. Under high-level management, corn can be grown year after year on the nearly level soils.

Controlling erosion is the most important management requirement. Terraces are the most effective means of control. Grassed waterways remove water safely from the terraces and thus prevent gullying. They should be prepared a year before the terraces are built. Stripcropping is advisable. If slopes are stripcropped on the contour, every other strip should remain in sod; no two adjoining strips should be in clean-tilled crops. Mora soils should be cultivated slightly off the contour, because internal drainage is slightly restricted. On slopes that are too uneven or too complex for contour farming and stripcropping, erosion can be controlled by means of cropping systems, adequate fertilization, and crop-residue management. Planting corn by the wheel-track method causes less compaction than other methods and thus allows more moisture to infiltrate before it runs off. After fall plowing, fields should be left rough through the winter.

All crops respond well to fertilization. Starter fertilizer is needed. More nitrogen is needed if corn is grown every year than if corn follows a legume or a green-manure crop in the cropping system. Both phosphate and potash are beneficial.

These soils are well suited to pasture. Some areas are poorly wooded and brushy. Clearing these areas and seeding them to a grass-legume mixture should be considered. An alfalfa-brome-timothy mixture is suitable, and it provides more forage than bluegrass. Fertilizer should be applied as a topdressing early in spring or in fall.

These soils support medium to good stands of mixed hardwoods. Most of the woodland is unmanaged and is used as pasture. This acreage should be either managed as woodland or cleared and used as cropland and pasture. Suggestions on woodland management are given under the heading "Woodland group 6" in the section "Woodland."

Odd areas and field borders can be planted to provide food and cover for wildlife. The plantings should include evergreens, shrubs, legumes, and grasses. White spruce, white pine, redcedar, Russian-olive, honeysuckle, lilac, and Siberian crabapple are suitable trees and shrubs. If there is adequate winter cover for pheasants, corn or small grain should be left or planted to provide them with food.

Capability unit IIw–1

This unit consists of deep, nearly level, somewhat poorly drained loams and fine sandy loams on uplands. These are soils of the Dundas and Ronneby series. Varying numbers of stones and cobblestones occur throughout the profiles. Fertility is moderate. The organic-matter content is medium. Permeability is moderately low, and the moisture-holding capacity is moderate to high. Erosion is no problem. The Ronneby soil has a fragipan that tends to cause a perched water table. The pan begins at a depth of about 16 inches.

If drained and otherwise well managed, these soils are highly productive. They are suitable for all crops grown in the county except alfalfa. Corn or grain can be grown year after year under high-level management.

Controlling internal wetness, maintaining fertility, and preserving tilth are the important management requirements. Diversion ditches can be used to prevent the accumulation of excess surface water, which is generally a problem in spring and after heavy rains. Fall plowing is advisable, because these soils are somewhat wet and cold and become cloddy if plowed when wet. Returning crop residue, applying manure, and growing legumes and grasses improve tilth and fertility.

Starter fertilizer is needed, because these soils warm up slowly in spring. More nitrogen is needed if corn is grown every year than if corn follows a legume or a green-manure crop in the cropping system. Phosphate and potash are beneficial.

These soils make very good pasture. They hold water well throughout the growing season. Most of the permanent pastures, however, are partly wooded, brushy, and undrained. Clearing these areas and using them as improved pasture or rotation cropland should be considered. Good grazing is afforded either by well-managed pasture seeded to a mixture of a tall grass and a legume or by a pasture of native bluegrass. A mixture of bromegrass, red clover, and alsike clover is well suited also. Fertilizer should be applied as a topdressing early in spring or in fall. Grazing should be delayed until the soil becomes firm.

These soils also are productive of wetland hardwoods. Most of the woodland is unmanaged and is used as pasture. This acreage should be either managed as woodland or cleared and used as cropland and rotation pasture. Suggestions on woodland management are given under the heading "Woodland group 8" in the section "Woodland."

Odd areas and field borders can be planted to provide food and cover for wildlife. The plantings should include evergreens, shrubs, legumes, and grasses. White spruce, white pine, Russian-olive, lilac, and Siberian crabapple are suitable trees and shrubs. Red clover and alsike clover are the best legumes.

Capability unit IIw–2

One land type, Alluvial land, makes up this unit. This land type consists of well drained or moderately well drained soil material that has been deposited recently by streams on bottom lands. This material varies widely in texture and is generally stratified. Fertility is moderately high or high. Permeability is moderate, and the moisture-holding capacity is moderately high or high. Occasional flooding and periodic wetness are moderate limitations. Erosion is no problem.

If well managed, this land type is highly productive of all crops commonly grown in the county. Corn and small grain can be grown year after year under high-level management. Occasionally, it is advisable to plant a sod crop, a green-manure crop, or a cover crop to supply organic matter and preserve tilth. Occasional flooding in spring sometimes delays planting.

Starter fertilizer is needed. More nitrogen is needed if corn is grown every year than if corn follows a legume or a green-manure crop in the cropping system. Both phosphate and potash are beneficial.

This land type also is suitable for pasture. It holds moisture well throughout the growing season. Some areas are wooded and brushy. Clearing these areas and using them as improved pasture or rotation cropland should be considered. Good grazing is afforded by well-managed pasture seeded to a mixture of a tall grass and a legume or by a pasture of bluegrass.

Many areas of this land type are brushy, unmanaged woodland. Suggestions on woodland management are given under the heading "Woodland group 9" in the section "Woodland."

Odd areas and field borders can be planted to provide food and cover for wildlife. The plantings should include evergreens, shrubs, legumes, and grasses.

Capability unit IIs–1

This unit consists of nearly level or gently sloping, well-drained, slightly droughty loams and silt loams on outwash plains and terraces. These are soils of the Becker, Fairhaven, and Wadena series. They are underlain by sand and gravel at a depth of 24 to 36 inches. Fertility is moderate. The organic-matter content is medium to high. Permeability is moderate or moderately rapid, and the moisture-holding capacity is moderate. The erosion hazard is slight or moderate.

These soils are well suited to all crops commonly grown in the county, including corn, soybeans, small grain, alfalfa, and other hay crops. Yields are good if management is good and if the moisture supply is adequate. Corn can be grown year after year under high-level management.

These soils are easy to till and can be tilled in spring or in fall. If they are tilled in spring, plow planting of row crops is advisable. This method causes less compaction than other methods and thus helps to control erosion. Most of the gentle slopes are short and irregular and are not suited to contour farming and stripcropping. Long, even slopes can be tilled on the contour.

Starter fertilizer is needed. More nitrogen is needed if corn is grown every year than if corn follows a legume or a green-manure crop in the cropping system. Both phosphate and potash are beneficial.

These soils make good permanent bluegrass pasture, but supplemental pasture generally is needed during prolonged dry periods. Grass-legume mixtures, such as alfalfa, bromegrass, and orchardgrass, provide more forage than bluegrass. Ordinarily, bluegrass is dormant in midsummer because of lack of moisture. Some areas make poor pasture because they are partly wooded and brushy. Clearing these areas and seeding them to a grass-legume mixture should be considered. Fertilizer should be applied as a topdressing early in spring or in fall. Rotation grazing is advisable, because it gives the plants a chance to recover.

These soils are better suited to cropland than to woodland. The few wooded areas that are now used as pasture should be cleared and used as cropland.

Odd areas and field borders can be planted to provide food and cover for wildlife. Winter cover generally is lacking. The plantings should include drought-resistant legumes, grasses, shrubs, and evergreens.

Capability unit IIIe–1

This unit consists of deep, sloping, well-drained fine sandy loams on uplands. These are soils of the Hayden and Milaca series. Fertility is moderate. The organic-matter content is low. Permeability is moderate, and the moisture-holding capacity is moderate to high. Unless protected, these soils are highly susceptible to erosion. The soils that have been used as woodland or permanent pasture are uneroded or only slightly eroded, but most of those that have been used as cropland have lost between one-third and two-thirds of the original surface layer.

Under high-level management, these soils make fairly good cropland.

Controlling erosion is the main management requirement. Terraces are the most effective means of control. Grassed waterways remove water safely from terraces and thus prevent gullying. They should be prepared a year before the terraces are built. The sides of the waterways and also those of gullies should be shaped and sodded to permanent vegetation. If these soils are stripcropped on the contour, the alternate strips should be planted to hay crops On slopes that are too complex or too uneven for contour farming, stripcropping, or terracing, erosion can be controlled by means of cropping systems, adequate fertilization, and crop-residue management. It is important that all residue be returned to the soil. Heavy applications of manure and permanent vegetation of grasses and legumes help to restore tilth and fertility and are effective measures for erosion control.

Starter fertilizer is needed. More nitrogen is needed if corn is grown every year than if corn follows a legume or a green-manure crop in the cropping system. Both phosphate and potash are beneficial.

These soils are well suited to pasture. Forage production is poor in areas that are partly wooded and brushy. Clearing and seeding these areas is advisable. An alfalfa-brome mixture is suitable, and it provides more forage than bluegrass. Fertilizer should be applied as a topdressing early in spring or in fall. Overgrazing should be avoided.

These soils support medium to good stands of mixed hardwoods. Much of the woodland is unmanaged or is used as pasture. If these soils are to be managed as woodland, they should be protected from fire and grazing. Suggestions on woodland management are given under the heading "Woodland group 6" in the section "Woodland."

Odd areas and field borders can be planted to provide food and cover for wildlife. The plantings should include evergreens, shrubs, legumes, and grasses. White spruce, white pine, redcedar, Russian-olive, honeysuckle, lilac, and Siberian crabapple are suitable trees and shrubs. If there is adequate winter cover for pheasants, corn and small grain should be left or planted to provide food for them.

Capability unit IIIe–2

This unit consists of gently sloping or undulating, somewhat excessively drained, somewhat droughty sandy loams on the outwash plain. These are soils of the Burkhardt, Chetek, Emmert, Estherville, Hayden, and Hubbard series. The Emmert and Hayden soils were derived from till and outwash gravel. The Hubbard soils are underlain by deep sand. The rest of the soils are underlain by sand and gravel at a depth of 18 to 24 inches. Fertility is low to moderate. The organic-matter content is low to medium. Permeability is rapid, and the moisture-holding capacity is low. All of these soils are susceptible to erosion. Some are uneroded, and some are only slightly eroded. Others have lost between one-third and two-thirds of their original surface layer.

These soils are suited to all crops commonly grown in the county, including corn, soybeans, small grain, alfalfa, and other hay crops. Yields are fair if management is good and if the supply of moisture is adequate.

Controlling wind erosion is the main management requirement. The soils warm up early in spring and are easy to till. They should be tilled in spring. Minimum tillage is advisable. All crop residue should be returned to the soil. Along with cropping systems and other conservation measures, residue management is an effective means of erosion control. Crop residue also supplies organic matter and improves the moisture-holding capacity.

All crops respond well to fertilization if the supply of moisture is adequate. Starter fertilizer is needed. More nitrogen is needed if corn is grown every year than if corn follows a legume or a green-manure crop in the

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cropping system. Both phosphate and potash are beneficial.

These soils make fair permanent bluegrass pasture, but supplemental pasture generally is needed. An alfalfa-brome mixture provides more forage than bluegrass. Therefore, it is usually better to use the second and third years of an alfalfa-brome hay crop as pasture than to maintain permanent bluegrass pasture. Some areas used as pasture are partly wooded and brushy. Clearing these areas and then seeding them to a grass-legume mixture should be considered. Fertilizer should be applied as a topdressing early in spring or in fall. Rotation of grazing is important, because it gives the plants a chance to recover.

These soils are low to medium producers of medium-quality hardwoods. Most of the woodland is unmanaged and is used as pasture. This acreage should be either managed as woodland and improved by replacing the hardwoods with pine or cleared and used as cropland and pasture. Suggestions on woodland management are given under the headings "Woodland group 1" and "Woodland group 2" in the section "Woodland."

Odd areas and field borders can be planted to provide food and cover for wildlife. The plantings should include evergreens, shrubs, legumes, and grasses. Pine, white spruce, redcedar, Russian-olive, lilac, and caragana are suitable trees and shrubs. If there is adequate winter cover for pheasants, corn and small grain should be left or planted to provide food for them.

Capability unit IIIw–1

One soil of the Adolph series is in this unit. It is a deep, nearly level or slightly depressional, poorly drained loam on uplands. Varying numbers of stones and cobblestones occur throughout the profile. Fertility is moderate. The organic-matter content is high. Permeability is moderately slow, and the moisture-holding capacity is moderate. Excess water is a severe limitation. Preserving tilth is a continuous problem if this soil is used as cropland. Erosion is no problem.

If drained and otherwise well managed, this soil is productive of corn and grain and is suited to red clover, alsike clover, Ladino clover, bromegrass, and timothy. It generally is not suited to alfalfa. Under high-level management, corn and grain can be grown year after year. Yields are good. Early maturing varieties of corn should be planted because of the frost hazard.

Drainage is the main management requirement. Open ditches and bedding are advisable. This soil is wet and cold and warms up slowly in spring. It should not be plowed when wet, because clods form. Fall plowing insures a good seedbed in spring. Returning crop residue, applying manure, and growing legumes and grasses improve tilth and fertility.

Starter fertilizer is needed. More nitrogen is needed if corn is grown every year than if corn follows a legume or a green-manure crop in the cropping system. Both phosphate and potash are beneficial.

These soils make very good pasture. They hold moisture well throughout the growing season. Most permanent pastures are undrained and partly wooded and brushy. Draining and clearing these areas and using them as improved pasture or rotation cropland should be considered. Good grazing is afforded by well-managed pasture seeded to a mixture of a tall grass and a legume or by a pasture of native bluegrass. A mixture of bromegrass, red clover, and alsike clover is well suited also. Fertilizer should be applied as a topdressing early in spring or in fall. Grazing should be delayed until the soil becomes firm. There are suitable sites for stock-water pits.

Most of the woodland is unmanaged and is used as pasture. This soil is better suited to cropland than to woodland. Developing it for cropland is advisable. Suggestions on woodland management are given under the heading "Woodland group 8" in the section "Woodland."

Odd areas and field borders can be planted to provide food and cover for wildlife. The plantings should include evergreens, shrubs, legumes, and grasses. Red clover and alsike clover are the best legumes. White-cedar is a preferred evergreen.

Capability unit IIIw–2

This unit consists of deep, nearly level or gently sloping, somewhat poorly drained loamy fine sands. These are soils of the Lino series. The water table is high. Fertility is low. The organic-matter content is low. Permeability is rapid, and the moisture-holding capacity is low. Excessive internal wetness and low fertility are the main limitations. If drained, these soils become slightly droughty during prolonged dry periods and are susceptible to wind erosion.

If drained and fertilized, these soils are suited to all crops grown in the county, including corn, grain, and legumes and grasses, such as red clover, alsike clover, Ladino clover, bromegrass, and timothy. Alfalfa stands are likely to be short lived. Under high-level management, corn and grain can be grown year after year.

Controlling wetness and increasing fertility are the main management requirements. Shallow ditches or grassed waterways prevent the accumulation of excess surface water. Tile drainage is not advisable.

Starter fertilizer is needed, because these soils are wet and cold and warm up slowly in spring. More nitrogen is needed if corn is grown every year than if corn follows a legume or a green-manure crop in the cropping system. Both phosphate and potash are beneficial.

Most permanent pastures are undrained and partly wooded and brushy. Draining and clearing these areas for use as improved pasture or rotation cropland should be considered. Well-managed pasture seeded to a grass-legume mixture provides good grazing. Fertilizer should be applied as a topdressing early in spring or in fall.

The growth of trees is good on these soils, but many woodlots are unmanaged and most are grazed. Suggestions on woodland management are given under the heading "Woodland group 9" in the section "Woodland."

Odd areas and field borders can be planted to provide food and cover for wildlife. The plantings should include evergreens, shrubs, legumes, and grasses. White spruce, white pine, redcedar, Russian-olive, lilac, and caragana are suitable trees and shrubs. Red clover and alsike clover are the most suitable legumes.

Capability unit IIIw–3

This unit consists of peat and muck, which formed from partly decomposed vegetation in low, wet depressions and bogs. Peat is more fibrous than muck and is less decayed. In some areas peat and muck are underlain by unclassified material at a depth of 42 inches. In others they are underlain by loam at a depth of 12 to 42 inches. Fertility is low. The moisture-holding capacity is high. Wetness is a severe limitation. Frost is a hazard. If the soils are too dry, fire is a hazard.

If drained and fertilized, these soils are suited to corn and soybeans, which are the main crops, and to small grain, red clover, alsike clover, and timothy. They are well suited to vegetable crops, including potatoes, onions, carrots, and radishes. Under high-level management, row crops can be grown year after year. Undrained areas of these soils are used as pasture, meadow, and wildlife habitat.

Drainage is the main management requirement. Open ditches can be used as outlets. Either open ditches or tile can be used as laterals. Water-level controls are needed to keep the soils from becoming too dry.

The short-straw variety of small grain should be grown, because lodging is a serious problem. Because of the frost hazard, only early maturing varieties of crops should be planted. Grasses and legumes should be grown occasionally to supply fresh organic matter and to control wind erosion. A cover crop of winter rye is an effective means of control and also improves tilth. Finely divided peats and mucks that have been farmed intensively for many years are likely to need a green-manure crop periodically. Windstrips or field windbreaks are needed if vegetables are grown.

It is advisable to apply manure as soon as the soils are drained. The manure hastens decay of the organic matter to a form more readily available to plants. Starter fertilizer is needed, because these soils are wet and cold and warm up slowly in spring. Nitrogen should be applied according to the needs of the crop. Generally, large applications of phosphate and potash are needed.

If otherwise well managed, undrained areas of these soils are suitable for pasture. The soils should be worked during a dry season, fertilized, and then seeded to reed canarygrass. If well established, this type of grass forms a tough, dense sod that supports grazing animals and hay equipment, even when the soils are somewhat wet. It is superior to and more palatable than native marsh hay. Areas where these soils, peat particularly, are shallow over loam make good sites for stock-water pits.

These soils are not suitable for woodland. A poor growth of willow, tamarack, and brush occurs in several undrained areas. Field windbreaks are needed in cultivated areas. Facts about woodland are given under the heading "Woodland group 10" in the section "Woodland."

The marshy, seasonally ponded, undrained areas of these soils are ideal as habitat for ducks, pheasants, and muskrats. Shallow pits and level ditches are desirable also. Seeding ditchbanks and the edges of stock-water pits to grasses and legumes furnishes food and cover. Grazing and mowing should be delayed until after the middle of July to protect wildlife during the nesting season. All areas should be protected from fire.

Capability unit IIIs–1

This unit consists of nearly level, somewhat excessively drained, somewhat droughty sandy loams on the outwash plain. These are soils of the Burkhardt, Chetek, Estherville, and Hubbard series. Hubbard soils are underlain by deep sand. The other soils have a shallow surface layer and are underlain by gravel and sand at a depth of 18 to 24 inches. Fertility is low to moderate. The organic-matter content is medium to low. Permeability is rapid, and the moisture-holding capacity is low. All of these soils are susceptible to erosion. Some are uneroded, and some are only slightly eroded. Others are moderately eroded and have lost between one-third and two-thirds of their original surface layer.

These soils are suited to all crops grown in the county, including corn, soybeans, small grain, alfalfa, and other hay crops. Corn can be grown year after year if the soils are protected by shelterbelts every 20 rods and are otherwise well managed. Yields of all crops are fair if the supply of moisture is adequate throughout the growing season. These soils respond to irrigation. If irrigated, they are well suited to truck crops. Nearby streams and, in places, sandpits are good sources of irrigation water.

Droughtiness and wind erosion are the main limitations. These soils warm up early in spring and are easy to till. Tillage in spring and minimum tillage are advisable. All crop residue should be returned to the soil. Residue management improves the moisture-holding capacity, supplies organic matter, and, along with cropping systems and other conservation measures, helps to control erosion.

All crops respond well to fertilization if the supply of moisture is adequate. Starter fertilizer is needed. More nitrogen is needed if corn is grown every year than if corn follows a legume or a green-manure crop in the cropping system. Both phosphate and potash are beneficial.

These soils make fair permanent bluegrass pasture, but supplemental pasture generally is needed. An alfalfa-brome mixture provides more forage than bluegrass, which is likely to be dormant during prolonged dry periods. Therefore, it is usually better to use the second and third years of an alfalfa-brome hay crop as pasture than to maintain permanent bluegrass pasture. Some areas used as pasture are wooded and brushy. Clearing these areas and then seeding them to a grass-legume mixture should be considered. Fertilizer should be applied as a topdressing early in spring or in fall. Rotation of grazing is advisable, because it gives the plants a chance to recover.

These soils are medium to low producers of medium-quality hardwoods. Most of the woodland is unmanaged and is used as pasture. This acreage either should be managed as woodland and improved by replacing the hardwoods with pine or should be cleared and used as cropland and pasture. Suggestions on woodland management are given under the headings "Woodland group 1" and "Woodland group 2" in the section "Woodland."

Odd areas and field borders can be planted to provide food and cover for wildlife. The plantings should include evergreens, shrubs, legumes, and grasses. Pine, white spruce, redcedar, Russian-olive, and caragana are suitable trees and shrubs. If there is adequate winter cover for pheasants, corn and small grain should be left or planted to provide food for them.

Capability unit IIIs–2

This unit consists of nearly level or gently sloping, well drained or moderately well drained, somewhat droughty loamy fine sands. These are soils of the Braham and Pomroy series. They occur in a transition zone between the till plain and the outwash sands. These soils are underlain by medium-textured material at a depth of 24 to 42 inches. Fertility is low. The organic-matter content is low. Permeability is rapid in the sandy part of the soils but moderate or moderately slow in the substratum. The moisture-holding capacity is low. The erosion hazard is slight or moderate. The moderately eroded soils have lost between one-third and two-thirds of their original surface layer.

These soils are well suited to all crops grown in the county, including corn, soybeans, small grain, alfalfa, and other hay crops. Corn can be grown year after year if the soils are protected by shelterbelts every 20 rods and are otherwise well managed. Adequate moisture is needed. These soils respond well to irrigation.

Droughtiness, low fertility, and wind erosion are the main limitations. These soils warm up early in spring and are easy to till. They should be tilled early in spring. Minimum tillage is advisable. Returning crop residue and applying manure improve the moisture-holding capacity and the fertility and, along with field windbreaks and other conservation measures, help to control erosion. On slopes that are too short and too irregular for stripcropping, terracing, and contour farming, erosion can be controlled by means of minimum tillage, crop-residue management, and adequate cropping systems.

All crops respond well to fertilization if the supply of moisture is adequate. Starter fertilizer is needed. More nitrogen is needed if corn is grown every year than if corn follows a legume or a green-manure crop in the cropping system. Both phosphate and potash are beneficial.

These soils make fair pasture. Permanent pasture grasses, including bluegrass, grow well in spring and early in summer but are dormant during prolonged dry periods. Bromegrass and alfalfa provide more forage than bluegrass. Therefore, it is better to use the second and third years of an alfalfa-brome hay crop as pasture than to maintain permanent pasture. Fertilizer should be applied as a topdressing early in spring or in fall.

These soils are low producers of poor-quality hardwoods. Much of the woodland is grazed. This acreage should be either managed as woodland and improved by replacing the hardwoods with pine or cleared and used as cropland and pasture. Suggestions on woodland management are given under the heading "Woodland group 5" in the section "Woodland."

Odd areas and field borders can be planted to provide food and cover for wildlife. The plantings should consist of drought-resistant evergreens, shrubs, legumes, and grasses. White pine, red pine, white spruce, redcedar, Russian-olive, lilac, and caragana are suitable trees and shrubs. If there is adequate winter cover for pheasants, corn and small grain should be left or planted to provide food for them.

Capability unit IVe–1

This unit consists of deep, sloping or moderately steep, well-drained fine sandy loams on uplands. These are soils of the Hayden and Milaca series. Fertility is moderate. The organic-matter content is low. Permeability is moderate, and the moisture-holding capacity is moderate to high. The erosion hazard is severe. The soils that have been used as woodland or permanent pasture are uneroded or only slightly eroded, but those that have been used as cropland have lost between one-third and two-thirds of their original surface layer. The moderately steep, severely eroded soils have lost more than two-thirds of their original surface layer.

These soils make fairly good cropland but should be used only occasionally for row crops. They are well suited to alfalfa.

Controlling erosion is the main management requirement. Except where the slope is too short or too irregular, contour stripcropping is the most efficient means of control. Terraces generally are not suitable. If these soils are used for row crops and small grain, they should be plowed in spring. Hay should be grown in the alternate strips, and all crop residue should be left. Wheeltrack planting is advisable if corn is grown. Waterways should be established and maintained wherever needed. The sides of both waterways and gullies should be shaped, seeded to grass, and then kept permanently in vegetation.

All crops respond well to manure and commercial fertilizer. Severely eroded soils should receive extra heavy applications of manure. Starter fertilizer is needed.

If fertilized and otherwise well managed, these soils make good permanent bluegrass pasture. A mixture of alfalfa and bromegrass, however, provides more forage than bluegrass. Many areas now produce poor forage because they are partly wooded and brushy. Clearing these areas and seeding them to a grass-legume mixture should be considered. Fertilizer should be applied as a topdressing early in spring or in fall.

These soils support medium to good stands of mixed hardwoods. Much of the woodland is unmanaged or is used as pasture. If these soils are to be managed as woodland, they should be protected from fire and grazing. Suggestions on woodland management are given under the headings "Woodland group 6" and "Woodland group 7" in the section "Woodland."

Odd areas and field borders can be planted to provide food and cover for wildlife. The plantings should include evergreens, shrubs, legumes, and grasses. White spruces, white pine, redcedar, Russian-olive, honeysuckle, lilac, and Siberian crabapple are suitable trees and shrubs. If there is adequate winter cover for pheasant, corn and small grain should be left or planted to provide food for them.

Capability unit IVe-2

This unit consists of sloping or rolling, somewhat excessively drained, somewhat droughty sandy loams on the outwash plain. These are soils of the Chetek, Emmert, Estherville, Hayden, and Hubbard series. Emmert and Hayden soils were derived from till and outwash gravel. Hubbard soils are underlain by deep sand. The other soils have a shallow surface layer and are underlain by sand and gravel at a depth of 18 to 24 inches. Fertility is low to moderate. The organic-matter content is medium to low Permeability is rapid, and the moisture-holding capacity is low. All of these soils are susceptible to erosion. Some are uneroded and some are only slightly eroded, but others have lost between one-third and two-thirds of their original surface layer.

These soils are suited to corn, oats, hay, and pasture grasses. Yields are fair if management is good and if the supply of moisture is adequate throughout the growing season.

These soils are easy to till. Controlling erosion is the main management requirement. Minimum tillage, wheel-track planting, crop-residue management, and adequate cropping systems are the most effective means of control. In most places the slope is too short and too irregular to be suitable for contour farming and stripcropping. Tillage in spring is advisable. Applying manure increases the capacity of the soils to hold water.

All crops respond to fertilization if the moisture supply is adequate. Starter fertilizer is needed. More nitrogen is needed if corn is grown every year than if corn follows a legume or a green-manure crop in the cropping system. Both phosphate and potash are beneficial. Heavy applications of manure increase the organic-matter content.

These soils make fair permanent bluegrass pasture, but supplemental pasture generally is needed. An alfalfa-brome mixture provides more forage than bluegrass, which is likely to be dormant during prolonged dry periods. Therefore, it is usually better to use the second and third years of an alfalfa-brome hay crop as pasture than to maintain permanent bluegrass pasture. Some areas used as pasture are partly wooded and brushy. Clearing these areas and seeding them to a legume-grass mixture should be considered. Fertilizer should be applied as a topdressing early in spring or in fall. Rotation grazing is important because it gives the plants a chance to recover.

These soils are low to medium producers of medium-quality hardwoods. Most of the woodland is unmanaged, and much of it is grazed. Pine grows well on these soils. It can be used for solid plantings or for improving the existing woodland. Suggestions on woodland management are given under the headings "Woodland group 1" and "Woodland group 2" in the section "Woodland."

Odd areas and field borders can be planted to provide food and cover for wildlife. The plantings should include evergreens, shrubs, legumes, and grasses. Pine, white spruce, redcedar, Russian-olive, lilac, and caragana are suitable trees and shrubs. If there is adequate winter cover for pheasants, corn and small grain should be left or planted to provide food for them.

Capability unit IVw-1

One land type, Loamy wet land, is in this unit. This land type is poorly drained or very poorly drained. It occurs as depressions in the till areas and in the adjacent lacustrine and outwash flats The surface layer ranges from loam to silty clay loam in texture and in places has a thin peat cap. The soil material is deep or moderately deep over calcareous gray till, noncalcareous red till, lacustrine silt, or outwash sand and gravel, depending on the location. Fertility is moderate to high. The organic-matter content is high. Permeability is moderate or moderately slow, and the moisture-holding capacity is moderate to high. Excess water is a severe limitation.

If adequately drained and fertilized, this land type is moderately productive of corn, grain, and hay. The depressions underlain by red and gray till generally are not suited to alfalfa, but they are suited to red clover, alsike clover, Ladino clover, bromegrass, and timothy. The depressions underlain by lacustrine and outwash material are suited to all crops grown in the county. Alfalfa stands, however, are likely to be short lived. If undrained, this land type generally is covered with water in spring and early in summer and supports aquatic grasses, sedges, and willows.

Controlling internal wetness and preserving tilth are the main management requirements. Drainage is essential if this soil material is to be used as cropland. Open ditch drainage is advisable. This material is wet and cold and warms up slowly in spring. It should not be plowed when wet, because clods form. Fall plowing insures a good seedbed in spring. Only early maturing varieties of corn should be planted, because of the frost hazard. Returning crop residue, applying manure, and growing grasses and legumes improve tilth and fertility.

Starter fertilizer is needed. More nitrogen is needed if corn is grown every year than if corn follows a legume or a green-manure crop in the cropping system. Both phosphate and potash are beneficial.

Undrained pastures can be improved by plowing early in fall when the soil material is dry enough to be worked, planting reed canarygrass and timothy right after plowing, and then broadcasting legume seed in spring. Fertilizer should be applied as a topdressing early in spring or in fall. Use of pastures should be deferred until the ground is firm. This land type provides good sites for stock-water pits.

This land type generally is unsuitable for use as woodland. Many areas support a sparse growth of willow and alder. Facts about woodland are given under the heading "Woodland group 11" in the section "Woodland."

The aquatic grasses, sedges, and willows in undrained areas make ideal wildlife habitat. These areas should be protected from fire.

Capability unit IVw-2

This unit consists of deep, poorly drained and very poorly drained loamy fine sands, shallow peat-capped sands, and small islands of wet sand within areas of peat. These soils occur as broad flats and depressions on the outwash plain. They have a high water table, and all are saturated. The sands are soils of the Isanti and

Lino series. Fertility is low. The organic-matter content is high. Permeability is rapid, and the moisture-holding capacity is low. Excess water is a severe limitation. Erosion is no problem.

If adequately drained and fertilized, these soils produce poor to fair yields of corn, hay, and grain. They are suited to red clover, alsike clover, Ladino clover, bromegrass, and timothy but generally are not suited to alfalfa. If undrained, these soils generally are covered with water in spring and early in summer and support aquatic grasses, sedges, and willows.

Capability unit IVw–3

Peat and muck make up this unit. These soils are 12 to 42 inches thick over sand. They formed in partly decomposed vegetation and occur in wet depressions and bogs on the outwash plain and along streams that frequently overflow. Peat is more fibrous than muck and is less decayed. Fertility is low. The moisture-holding capacity is high. Wetness and shallowness are severe limitations. Both frost and fire are hazards.

If adequately drained, these soils are suited to corn, small grain, vegetables, red clover, alsike clover, and timothy. Most undrained areas are used as pasture and meadow, but some are used only as wildlife habitat.

Drainage is the main management requirement, if enough water can be removed to make the soils suitable for cropland or improved pasture. Open ditches can be used as outlets and laterals. Tile is not suitable. Adequate water-level controls are needed to keep the soils from becoming too dry. Dry organic soils can be damaged by fire, and if the thin peat cap is burned off, the generally sterile underlying sand is exposed. Stabilizing and maintaining ditchbanks is a problem.

Controlling surface water and improving internal drainage are the main management requirements. Drainage is essential if crops are to be grown. Open-ditch drainage is advisable.

Starter fertilizer is needed, because these soils are wet and cold and warm up slowly in spring. Only early maturing varieties of corn should be used, because of the frost hazard. More nitrogen is needed if corn is grown every year than if corn follows a legume or a green-manure crop in the cropping system. Both phosphate and potash are beneficial.

Undrained pastures can be improved by plowing early in fall when the soils are dry enough to be worked, planting reed canarygrass and timothy right after plowing, and then broadcasting legume seed in spring. Grazing should be deferred until the ground is firm. These soils generally provide good sites for stock-water pits.

These soils are unsuitable for woodland. A sparse growth of willow and alder occurs in many areas. Facts about woodland are given under the heading "Woodland group 11" in the section "Woodland."

The marshy, seasonally ponded, undrained areas of these soils provide ideal habitat for ducks, pheasants, and muskrats. Shallow pits and level ditches would be desirable also. Ditchbanks and the edges of stock-water pits should be seeded to grasses and legumes to furnish wildlife food and cover. Grazing and mowing should be delayed until after the middle of July, so as to protect wildlife during the nesting season. All areas should be protected from fire.

Because of the frost hazard, only early maturing varieties of crops should be planted. It is advisable to use short-straw varieties of small grain, because lodging is a serious problem. Grasses and legumes should be grown occasionally to supply fresh organic matter and to control wind erosion. A cover crop of winter rye improves tilth and also helps to control erosion. Finely divided peats and mucks that have been farmed intensively for many years are likely to need a green-manure crop periodically. Windstrips or field windbreaks are needed if vegetables are grown.

It is advisable to apply manure as soon as the soils are drained. The manure hastens decay of the organic matter to a form more readily available to plants. Starter fertilizer is needed, because these soils are wet and cold and warm up slowly in spring. Nitrogen should be applied according to the needs of the crop. Generally, large applications of phosphate and potash are needed.

If otherwise well managed, undrained areas of these soils make suitable pasture. The soils should be worked during a dry season, fertilized, and then seeded to reed canarygrass. If well established, this type of grass forms a tough, dense sod that supports grazing animals and hay equipment, even when the soils are somewhat wet. It is superior to and more palatable than marsh hay.

These soils are not suitable for woodland. A poor growth of willow, tamarack, and brush occurs in several undrained areas. Field windbreaks are needed in cultivated areas. Facts about woodland are given under the heading "Woodland group 10" in the section "Woodland."

The marshy, seasonally ponded, undrained areas of these soils provide ideal habitat for ducks, pheasants, and muskrats. Shallow pits and level ditches would be desirable also. Ditchbanks and the edges of stock-water pits should be seeded to grasses and legumes to furnish wildlife food and cover. Grazing and mowing should be delayed until after the middle of July, so as to protect wildlife during the nesting season. All areas should be protected from fire.

Capability unit IVs–1

This unit consists of nearly level to rolling, excessively drained, very droughty loamy sands on the outwash plain. These are soils of the Emmert and Salida series. They are underlain by gravel and sand at a depth of 6 to 18 inches. Fertility is low. The organic-matter content is medium to low. Permeability is very rapid, and the moisture-holding capacity is very low. The hazard of both wind and water erosion is severe in cultivated areas. Some of these soils are uneroded, and some are only slightly eroded. Others are moderately eroded and have lost between one-third and two-thirds of their original surface layer.

These soils are marginal but can be used as cropland. Corn, soybeans, rye, and alfalfa are the crops commonly grown. Yields are poor. The supply of moisture generally is insufficient for corn and soybeans, and the shallowness of the soils over gravel makes it difficult to grow

a satisfactory stand of alfalfa. Corn can be grown on the level soils year after year if management is good and if field windbreaks are established every 20 rods.

Droughtiness and the erosion hazard are the main limitations. The cropping system should provide year-round cover, and all residue should be left on the soil. Wind stripcropping, field windbreaks, and stubble-mulch tillage also are effective means of erosion control. On slopes that are too short or too irregular for stripcropping, terracing, or contouring, erosion can be controlled by means of minimum tillage, crop-residue management, and adequate cropping systems. Because of droughtiness, only the early maturing crop varieties should be grown.

All crops respond to fertilization if the supply of moisture is adequate. Starter fertilizer is needed. More nitrogen is needed if corn is grown every year than if corn follows a legume or a green-manure crop in the cropping system. Both phosphate and potash are beneficial. Grass-legume crops and manure supply organic matter.

These soils make poor permanent bluegrass pasture because of droughtiness. Growing a grass-legume crop and using the hay as rotation pasture is advisable. Alfalfa and bromegrass are more drought resistant than bluegrass and provide more forage. Fertilizer should be applied as a topdressing early in spring or in fall.

These soils are low producers of medium-quality hardwoods. Pine grows fairly well on these soils. It can be used for solid plantings or for improving the existing woodland. Suggestions on woodland management are given under the heading "Woodland group 3" in the section "Woodland."

Odd areas and field borders can be planted to provide food and cover for wildlife. The plantings should include evergreens, shrubs, legumes, and grasses. Pine, white spruce, redcedar, Russian-olive, lilac, and caragana are suitable trees and shrubs. If there is adequate winter cover for pheasants, corn and small grain should be left or planted to provide food for them.

Capability unit IVs–2

This unit consists of sloping or rolling, well drained or moderately well drained, somewhat droughty loamy fine sands. These are soils of the Braham series. They occur in the transition zone between the till plain and the outwash sands. They are underlain by medium-textured material at a depth of 24 to 42 inches. Fertility is low. The organic-matter content is low. Permeability is rapid in the sandy part of the soil but moderate in the substratum. The moisture-holding capacity is low. The erosion hazard is slight or moderate. The moderately eroded soils have lost between one-third and two-thirds of their original surface layer.

These soils are used as cropland, but yields are poor. Corn, oats, hay, and pasture grasses are the main crops.

These soils warm up early in spring and are easy to cultivate. Droughtiness, low fertility, and the hazard of erosion are the main limitations. Applying manure and returning all crop residue improve the moisture-holding capacity and help to control erosion. Contour stripcropping, contour farming, minimum tillage, and adequate cropping systems also are effective means of erosion control.

All crops respond well to fertilization if the supply of moisture is adequate. Starter fertilizer is needed. Grass-legume crops and manure supply organic matter.

These soils make poor permanent bluegrass pasture because of droughtiness. Growing a grass-legume crop and using the hay as rotation pasture is advisable. Alfalfa and bromegrass are more drought resistant than bluegrass and provide more forage. Fertilizer should be applied as a topdressing early in spring or in fall.

These soils are low producers of poor-quality hardwoods. Pine grows well on these soils. It can be used for solid plantings or for improving the existing woodland. Suggestions on woodland management are given under the heading "Woodland group 5" in the section "Woodland."

Odd areas and field borders can be planted to provide food and cover for wildlife. The plantings should include evergreens, shrubs, legumes, and grasses. Pine, white spruce, redcedar, Russian-olive, lilac, and caragana are suitable trees and shrubs. If there is adequate winter cover for pheasants, corn and small grain should be left or planted to provide food for them.

Capability unit IVs–3

This unit consists of deep, nearly level and gently sloping, excessively drained, droughty loamy sands and loamy fine sands on the outwash plain. These are soils of the Hubbard and Zimmerman series. Fertility is low or very low. The organic-matter content is medium to low. Permeability is rapid, and the moisture-holding capacity is very low. Wind erosion is a serious hazard in cultivated areas. Some of these soils are uneroded, and some are only slightly eroded. Others are moderately eroded and have lost between one-third and two-thirds of their original surface layer.

These soils are suited to corn, soybeans, rye, and alfalfa, but because of droughtiness, yields are poor. Corn can be grown on the level soils year after year if the soils are protected by windbreaks every 20 rods and are otherwise well managed.

Droughtiness and the erosion hazard are the most serious limitations. These soils warm up early in spring and are easy to till. They should be tilled early in spring. Minimum tillage is advisable. The cropping system should provide year-round cover. Returning all crop residue and applying manure are ways to improve the moisture-holding capacity, help protect the soils against erosion, and increase the organic-matter content. Wind stripcropping, field windbreaks, and stubble-mulch tillage also are effective means of erosion control. On slopes that are too short or too irregular for stripcropping, terracing, or contouring, erosion can be controlled by means of minimum tillage, crop-residue management, and adequate cropping systems.

All crops respond well to fertilization if the supply of moisture is adequate. Starter fertilizer is needed. More nitrogen is needed if corn is grown every year than if corn follows a legume or a green-manure crop in the cropping system. Both phosphate and potash are beneficial. Grass-legume crops and manure supply organic matter.

These soils make poor permanent bluegrass pasture. Bluegrass produces poor sod and is unproductive during prolonged dry periods. Pasturing a hay crop the second year is advisable. An alfalfa-brome mixture is more resistant to drought than bluegrass and produces more forage. Many wooded and brushy areas on Zimmerman and Hubbard soils (fig. 12) are now used as pasture. Clearing these areas and using them as rotation cropland and pasture should be considered. Fertilizer should be applied as a topdressing early in spring or in fall.

These soils are low producers of poor-quality hardwoods. Pine grows well on these soils. It can be used for solid plantings and for improving the existing woodland. Suggestions on woodland management are given under the heading "Woodland group 1" in the section "Woodland."

Figure 12.—**Unmanaged woodland used as pasture. The soil is Hubbard loamy sand, 0 to 2 percent slopes. It is in capability unit IVs–3.**

Odd areas and field borders can be planted to provide food and cover for wildlife. The plantings should include evergreens, shrubs, legumes, and grasses. Pine, white spruce, redcedar, Russian-olive, lilac, and caragana are suitable trees and shrubs. If there is adequate winter cover for pheasants, corn and small grain should be left or planted to provide food for them.

Capability unit VIe–1

This unit consists of deep, moderately steep to very steep, well-drained fine sandy loams. These are soils of the Milaca and Hayden series. Fertility is moderate. The organic-matter content is low. Permeability is moderate, and the moisture-holding capacity is moderate to high. Runoff is rapid, and the erosion hazard is very severe. The soils that have been used as woodland and pasture are uneroded or only slightly eroded, but most of those that have been used as cropland have lost between one-third and two-thirds of their original surface layer and the rest have lost more than two-thirds.

These soils are suited to meadow, pasture, and woodland. Those now used as cropland should be seeded to permanent vegetation.

If fertilized and otherwise well managed, these soils make fair permanent pasture. Pastures and meadows can be improved by occasionally disking the soils and then seeding them to an alfalfa-brome mixture, which provides more forage than bluegrass. The old sod should be left on the surface to protect the soils from erosion until the new seedlings are established. Applications of manure and commercial fertilizer are needed to establish and maintain a good vegetative cover. Established meadows and rotation pastures should be topdressed annually with phosphate and potash, either early in spring or in fall. Overgrazing should be prevented.

These soils support medium to good stands of mixed hardwoods. Much of the woodland is unmanaged or is used as pasture. Pine grows well. It can be planted to improve the existing woodland. If these soils are to be managed as woodland, they must be protected from fire and grazing. Suggestions on woodland management are given under the heading "Woodland group 7" in the section "Woodland."

Wildlife habitat can be developed by planting evergreens, shrubs, legumes, and grasses. White pine, red pine, white spruce, redcedar, Russian-olive, honeysuckle, lilac, and Siberian crabapple are suitable trees and shrubs. In managed woodlots, two den trees per acre should be left for squirrels.

Capability unit VIe–2

This unit consists of rolling or hilly, somewhat excessively drained, droughty sandy loams. These are soils of the Chetek, Emmert, and Hayden series. The Chetek soil is underlain by gravel and sand at a depth of 18 to 24 inches. Emmert and Hayden soils were derived from till and outwash gravel. Fertility is low in all of these soils. The organic-matter content is low. Permeability is rapid, and the moisture-holding capacity is low. The erosion hazard is severe. Some of the soils are uneroded, and some are only slightly eroded. Others are moderately eroded and have lost between one-third and two-thirds of their original surface layer. The Chetek soil has lost more than two-thirds of its original surface layer.

These soils are suited to meadow, pasture, and woodland. Those now used as cropland should be seeded to permanent vegetation.

If fertilized and otherwise well managed, these soils make fair permanent bluegrass pasture. Pastures and meadows can be improved by occasionally disking the soils and then seeding them to an alfalfa-brome mixture, which provides more forage than bluegrass. The old sod should be left on the surface to protect the soils from erosion until the new seedlings are established. Applications of manure and commercial fertilizer are needed to establish and maintain a good vegetative cover. Established meadows and rotation pastures should be topdressed annually with phosphate and potash, either early in spring or in fall. Overgrazing should be prevented.

These soils are low to medium producers of mixed hardwoods. Most of the woodland is unmanaged, and much of it is grazed. Pine grows well. It can be used for solid plantings or for improving existing woodland. Suggestions on woodland management are given under the headings "Woodland group 2" and "Woodland group 3" in the section "Woodland."

Wildlife habitat can be developed by planting evergreens, shrubs, legumes, and grasses. White spruce, pine, redcedar, Russian-olive, honeysuckle, lilac, and caragana are suitable trees and shrubs. In managed woodlots, two den trees per acre should be left for squirrels.

Capability unit VIw–1

One land type, Alluvial land, frequently flooded, makes up this unit. This land type consists of well-drained to poorly drained soil material on low bottom land. The material varies widely in texture and generally is stratified. In many places it has a shallow cap of peat. Flooding is a severe limitation.

This land type is not suitable for row crops. Drainage is inadvisable because of the constant hazard of flooding. Control of flooding would be too costly to be worth while.

If cleared and well managed, the better drained areas make good pasture. These areas should be renovated and reseeded as necessary, and particularly if the sod has been covered with infertile sediments. If plowed, they should be reseeded as soon as possible. Grasses and legumes that tolerate flooding should be used. A companion crop of oats should be grazed or clipped; otherwise, it is likely to kill new seedlings. The poorly drained areas are difficult to renovate, because they are wet throughout the year. These areas can be seeded to reed canarygrass or to some other species that tolerates both flooding and poor drainage. Reed canarygrass should be seeded on frozen ground, either late in fall or early in spring. Pastures should not be grazed early in spring or after flooding, because the animals trample the turf.

Streambank stabilization is needed at sharp turns to keep streams from cutting into the areas used as cropland and pasture.

Much of the woodland is brushy and unmanaged. Suggestions on woodland management are given under the heading "Woodland group 9" in the section "Woodland."

In most places this land type supports abundant wildlife. The thick underbrush and the aquatic vegetation provide excellent cover and food and nesting places for upland game. Planting suitable conifers, shrubs, hedges, and grasses is advisable. All areas should be protected from fire.

Capability unit VIs–1

This unit consists of rolling or hilly, excessively drained, very droughty loamy sands and sandy loams on the outwash plain. These are soils of the Chetek and Emmert series. They are underlain by gravel and sand at a depth of 6 to 18 inches. Fertility is low. The organic-matter content is low. Permeability is very rapid, and the moisture-holding capacity is very low. The erosion hazard is severe. Some of these soils are uneroded, and some are only slightly eroded. The rest have lost between one-third and two-thirds of their original surface layer.

These soils are suited to meadow, pasture, woodland, and wildlife. Those now used as cropland should be seeded to permanent vegetation. Gullies should be shaped and seeded to make grassed waterways.

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These soils need to be well managed if they are to be used as pasture or meadow. Because of droughtiness, they make poor permanent bluegrass pasture. Pastures and meadows can be improved by occasionally disking the soils and then seeding them to an alfalfa-brome mixture, which resists drought better than bluegrass and provides more forage. The old sod should be left on the surface to protect the soils from erosion until the new seedlings are established. Applications of manure and commercial fertilizer are needed to establish and maintain a good vegetative cover. Established meadows and rotation pastures should be topdressed annually with phosphate and potash, either early in spring or in fall. Overgrazing should be prevented.

These soils are low producers of medium-quality hardwoods. Pine grows well. It can be used for solid plantings or for improving the existing woodland. Suggestions on woodland management are given under the heading "Woodland group 3" in the section "Woodland."

White spruce, red pine, white pine, redcedar, Russian-olive, chokecherry, caragana, legumes, and grasses should be planted to provide shelter for wildlife. In managed woodlots, two den trees per acre should be left for squirrels.

Capability unit VIs–2

One hilly, well drained or moderately well drained, somewhat droughty loamy fine sand of the Braham series makes up this unit. This soil occurs in the transition zone between the till and outwash plains. It is underlain by medium-textured material at a depth of 24 to 42 inches. Fertility is low. The organic-matter content is low. Permeability is rapid in the sandy part of the soil but moderate in the substratum. The moisture-holding capacity is low. Erosion is a hazard.

This soil is unsuitable for cropland because of droughtiness and the erosion hazard. It can be used as meadow, pasture, and woodland.

This soil makes poor permanent bluegrass pasture. Pastures and meadows can be improved by occasionally disking the soils and seeding them to an alfalfa-brome mixture, which resists drought better than bluegrass and provides more forage. The old sod should be left on the surface to protect the soil from erosion until the new seedlings are established. Applications of manure and commercial fertilizer are needed to establish and maintain a good vegetative cover. Established meadows and rotation pastures should be topdressed annually with phosphate and potash, either early in spring or in fall. Overgrazing should be prevented.

This soil is a low producer of poor-quality hardwoods. Pine grows well. It can be used for solid plantings or for improving existing woodland. Suggestions on woodland management are given under the heading "Woodland group 5" in the section "Woodland."

Wildlife habitat can be developed by planting evergreens, shrubs, legumes, and grasses. Pine, white spruce, redcedar, Russian-olive, lilac, and caragana are suitable trees and shrubs. In managed woodlots, two den trees per acre should be left for squirrels.

Capability unit VIs–3

This unit consists of one nearly level and gently sloping land type and deep, undulating or rolling, excessively drained, very droughty loamy sands and loamy fine sands on the outwash plain. The land type is Beach sand. The soils are those of the Hubbard and Zimmerman series. Fertility is low or very low. The organic-matter content is medium to low. Permeability is rapid, and the moisture-holding capacity is very low. The erosion hazard is severe in cultivated areas. Some of the soils are uneroded, some are only slightly eroded, others are moderately eroded, and the rest are severely eroded. Between one-third and two-thirds of the original surface layer has been removed from the moderately eroded soils, and more than two-thirds has been removed from the severely eroded soils.

These soils are suitable for meadow, pasture, and woodland. Those now used as cropland should be seeded to permanent vegetation. Plowing, if needed, should be done in spring just before planting. Minimum tillage is important. Managing crop residue and applying manure improve the moisture-holding capacity and help control erosion. Gullies should be shaped and seeded to make grassed waterways.

These soils make poor permanent bluegrass pasture. An alfalfa-brome mixture provides more forage than bluegrass. Applications of manure and commercial fertilizer are needed to maintain a good vegetative cover. Established meadows and rotation pastures should be topdressed annually with phosphate and potash, either early in spring or in fall.

These soils are low producers of poor-quality hardwoods. Pine grows well. It can be used for solid plantings or for improving existing woodland. Suggestions on woodland management are given under the heading "Woodland group 1" in the section "Woodland."

Wildlife habitat can be developed by planting evergreens, shrubs, legumes, and grasses. Pine, white spruce, redcedar, Russian-olive, lilac, and caragana are suitable trees and shrubs. In managed woodlots, two den trees per acre should be left for squirrels.

Capability unit VIIs–1

This unit consists of deep loamy sands and fine sands, shallow loamy sands and gravelly loamy sands, loamy fine sands, and gravelly outwash and loamy glacial till. These are soils of the Emmert, Hayden, Chetek, Hubbard, Salida, and Zimmerman series. All are rolling to very steep, excessively drained, and very droughty. Fertility is low. The organic-matter content is low. Permeability is rapid or very rapid, and the moisture-holding capacity is very low. The erosion hazard is severe. Some of these soils are uneroded or only slightly eroded, others have lost between one-third and two-thirds of their original surface layer, and the rest have lost more than two-thirds of their original surface layer.

These soils are suited to woodland and to wildlife habitat. They are not suited to cropland. They are poorly suited to pasture, because it is difficult to maintain a good vegetative cover. At best, yields of pasture grasses are poor. The soils now used as cropland should be seeded to permanent vegetation.

These soils are low producers of slow-growing, low-quality hardwoods. Red pine and jack pine grow fairly well. They can be used for solid plantings or for improving existing woodland. Suggestions on woodland management are given under the headings "Woodland group 1" and "Woodland group 3" in the section "Woodland."

White spruce, red pine, redcedar, Russian-olive, chokecherry, and caragana can be planted to provide shelter for wildlife. In managed woodlots, two den trees per acre should be left for squirrels.

Capability unit VIIIw–1

One land type, Marsh, makes up this unit. It occurs along lakes, streams, shallow basins, and ponds. Because of extreme wetness, this soil material is unclassified. The vegetation consists of cattails, rushes, sedges, willows, and other water-tolerant plants. The water level fluctuates, depending on the season. Some areas are dry during years of less than normal rainfall. During prolonged dry periods, the edges of the marsh can be cut for wild hay.

This land type is too wet to be suitable for cropland, woodland, or pasture. It provides ideal habitat for waterfowl, muskrat, mink, and upland game. It can be improved by leveling ditches and controlling the water level. All areas should be protected from fire.

If drained, the marshes can be used in much the same way as the soils in capability units IVw–1 and IVw–2. Special surveys would be needed to determine the feasibility of artificial drainage.

Estimated Yields

Table 2, beginning on p. 42, shows estimates of yields, under two levels of management, of the principal crops grown in Sherburne County.

In columns A are yields to be expected under average management. Average management is defined as follows.

For cultivated crops:

1. Surface and internal drainage are improved, but not enough to provide optimum growing conditions where natural drainage is restricted.
2. Moderate amounts of lime and fertilizer are applied, but a more adequate program of soil testing is needed.
3. Most crop residue is returned to the soil. If low-residue crops are grown, organic matter is supplied by growing cover crops and applying manure or other organic material.
4. Seedbed preparation is either inadequate or excessive, and the soil may be worked when either too wet or too dry.
5. Weeds and insects are not adequately controlled.
6. Crop variety, seed quality, and plant population are not considered for a specified soil or location.
7. Control of erosion is inadequate.

For hay and pasture grasses:

1. Drainage is improved, but not enough to provide optimum growing conditions where natural drainage is restricted.
2. Moderate amounts of lime and fertilizer are applied, but a more adequate program of soil testing is needed.

3 Reseeding is usually delayed until after the legumes have disappeared from the forage stand and the grasses show serious nitrogen deficiency.
4. Grass-legume stands are of medium quality, crop variety and seed quality or quantity are not considered, and seedbed preparation may be inadequate.
5. Field operations are usually timely.
6. The entire pasture is grazed, and it may be overgrazed late in summer and in fall.
7. Runoff and erosion on steep slopes are not controlled.

Yields given in columns B are those to be expected under high-level management. High-level management is defined as follows.

For cultivated crops:

1. Surface and internal drainage provide optimum growing conditions where natural drainage is restricted.
2. Lime, phosphate, potash, nitrogen, and other elements are applied according to crop needs and the needs indicated by soil tests.
3. All crop residue is returned to the soil. If low-residue crops are grown, organic matter is supplied by growing cover crops and by applying manure or other organic material.
4. Seedbed preparation is limited to that needed for crop production. Tillage is avoided when the soils are wet, and spring tillage is delayed until planting time. If plowed in fall, fields are left rough in winter. Green-manure crops are plowed under no earlier than October 1 of the seeding year.
5. Weeds and insects are adequately controlled.
6. Crop variety, seed quality, and plant population are considered for a specified soil and location.
7. Erosion is kept within tolerated limits.
8. Field operations are usually timely.

For hay and pasture grasses:

1. Surface and internal drainage provide optimum growing conditions.
2. Lime and fertilizer are applied at seeding time according to crop needs and the needs indicated by soil tests, and also are applied as topdressing as needed.
3. Stands are reseeded and re-established regularly.
4. Grass-legume stands are of high quality, and crop variety is considered for a specified soil and location.
5. Haymaking operations are timely.
6. Grazing is deferred and rotated as needed.

Woodland

Forest covers 58,500 acres in Sherburne County. Three major forest types occupy substantial acreages, and three others are represented by minor acreages.

The most extensive forest type in the county is the oak type. It covers 34,900 acres. Red oak is the most common species, but the stands include some bur oak and a little white oak. The trees generally are of poor quality.

The bottom-land hardwood type of forest covers 7,600 acres. It consists of American elm, black ash, and green ash. The aspen-birch type, which is predominantly aspen, covers 1,800 acres. The northern hardwood type covers 400 acres and is found on the finer textured soils. It is made up of hard maple, basswood, white oak, and red oak. Jack pine covers 400 acres. The swamp conifer type, which consists of black spruce and tamarack, also covers 400 acres. About 13,000 acres is covered with brush. The upland acreage has some potential for wood crops, but the lowland acreage generally has little value, because of wetness and flooding.

Wood production in this county has been very poor because oak is not well suited to sandy soils. Oak should be replaced with pine, preferably red pine.

Woodland Suitability Groups

Management of woodland can be planned more effectively if soils are grouped according to those characteristics that govern the growth of trees and affect the management of the stands. The soils of Sherburne County have been placed in 11 woodland suitability groups. Each group consists of soils that are suited to the same kinds of trees, that need the same management, and that have about the same potential productivity. A description of each of these 11 groups is given in the following pages. To find the woodland suitability classification for any given soil, refer to the "Guide to Mapping Units."

The factors considered in placing each soil in a woodland group include potential productivity, which is expressed as site index; species preferred for planting; and soil-related hazards and limitations to be considered in management. These factors are explained in the pages that follow.

The potential productivity of a soil for a given species is commonly expressed as site index. It is the height in feet that the dominant trees of a given species, growing on a specified soil, will reach at a specified age. On the basis of the site index, rates of growth and total yields can be calculated. Data on yields of pine on soils of specified site indexes are given in table 3, p. 46.

Seedling mortality refers to the expected loss of naturally occurring or planted seedlings, as a result of unfavorable soil characteristics. Mortality is *slight* if the expected loss is less than 25 percent. It is *moderate* if the expected loss is between 25 and 50 percent. Mortality is *severe* if the expected loss is more than 50 percent.

Plant competition refers to invasion by or growth of undesirable species when openings are made in the canopy. Competition is *slight* if invaders do not prevent adequate regeneration and early growth and do not interfere with the development of planted seedlings. It is *moderate* if the invaders delay but do not prevent the establishment of a normal, fully stocked stand. Competition is *severe* if invaders prevent adequate regeneration or if intensive site preparation and maintenance are needed.

TABLE 2.--ESTIMATED AVERAGE YIELDS PER ACRE OF PRINCIPAL CROPS UNDER TWO LEVELS OF MANAGEMENT

[Figures in columns A indicate yields under average management; figures in columns B indicate yields under high-level management. Absence of figure indicates the crop is not suited to or is not commonly grown on the soil specified]

Soil	Corn for grain		Corn for silage		Oats		Rye		Soybeans		Hay 1/		Rotation pasture 2/	
	A	B	A	B	A	B	A	B	A	B	A	B	A	B
	Bu.	Bu.	Tons	Tons	Bu.	Bu.	Bu.	Bu.	Bu.	Bu.	Tons	Tons	A.U.D. 3/	A.U.D. 3/
Adolph loam	35	60	7	11	35	55	----	----	15	22	1.5	3.0	75	150
Alluvial land	35	55	6	10	35	45	----	----	18	23	1.8	3.0	90	150
Alluvial land, frequently flooded	----	----	----	----	----	----	----	----	----	----	----	----	----	----
Beach sand	----	----	----	----	----	----	----	----	----	----	----	----	----	----
Becker loam, 0 to 2 percent slopes	50	60	9	11	50	60	----	----	20	25	2.5	3.5	125	175
Becker loam, 2 to 6 percent slopes	45	55	8	10	45	55	----	----	18	23	2.3	3.2	115	160
Braham loamy fine sand, 0 to 2 percent slopes	40	55	7	10	30	40	----	----	15	18	2.0	3.0	100	150
Braham loamy fine sand, 2 to 6 percent slopes	35	50	6	9	25	35	----	----	13	16	1.8	2.8	90	140
Braham loamy fine sand, 2 to 6 percent slopes, eroded	30	45	5	8	20	30	----	----	11	15	1.6	2.6	80	130
Braham loamy fine sand, 6 to 12 percent slopes	30	45	5	8	20	30	----	----	10	13	1.6	2.6	80	130
Braham loamy fine sand, 6 to 12 percent slopes, eroded	25	40	5	7	15	25	----	----	8	11	1.4	2.4	70	120
Braham loamy fine sand, 12 to 18 percent slopes	----	----	----	----	----	----	----	----	----	----	1.0	2.0	50	100
Burkhardt sandy loam, 0 to 2 percent slopes	40	50	7	9	30	40	----	----	17	20	2.0	3.0	100	150
Burkhardt sandy loam, 2 to 6 percent slopes	35	45	6	8	25	35	----	----	15	18	1.8	2.8	90	140
Burkhardt sandy loam, 2 to 6 percent slopes, eroded	30	40	5	7	20	30	----	----	12	15	1.6	2.6	80	130
Chetek sandy loam, 0 to 2 percent slopes	35	45	6	8	30	40	----	----	15	17	1.5	2.5	75	125
Chetek sandy loam, 2 to 6 percent slopes	30	40	5	7	25	35	----	----	12	15	1.3	2.3	65	115
Chetek sandy loam, 2 to 6 percent slopes, eroded	25	35	4	6	20	30	----	----	10	13	1.1	2.1	55	110
Chetek sandy loam, 6 to 12 percent slopes	25	35	4	6	20	30	----	----	10	13	1.1	2.1	55	110
Chetek sandy loam, 6 to 12 percent slopes, eroded	20	30	4	5	15	25	----	----	8	10	.9	1.8	45	90
Chetek sandy loam, 6 to 12 percent slopes, severely eroded	----	----	----	----	----	----	----	----	----	----	.7	1.5	35	75
Dundas loam	40	65	8	12	40	55	----	----	18	25	1.5	3.0	75	150
Emmert gravelly loamy sand, 6 to 12 percent slopes	----	----	----	----	----	----	----	----	----	----	.5	.8	25	40
Emmert gravelly loamy sand, 12 to 35 percent slopes	----	----	----	----	----	----	----	----	----	----	----	----	----	----
Emmert loamy sand, 0 to 2 percent slopes	30	40	5	7	25	35	15	25	10	15	1.2	2.0	60	100
Emmert loamy sand, 2 to 6 percent slopes	25	35	5	6	20	30	12	21	8	12	1.0	1.7	50	85
Emmert loamy sand, 2 to 6 percent slopes, eroded	20	30	4	5	15	25	8	12	6	10	.8	1.5	40	75

Emmert loamy sand, 6 to 12 percent slopes	----	----	----	----	----	----	----	----	----	----	.8	1.5	40	75
Emmert loamy sand, 6 to 12 percent slopes, eroded	----	----	----	----	----	----	----	----	----	----	.6	1.0	30	50
Emmert loamy sand, 6 to 12 percent slopes, severely eroded	----	----	----	----	----	----	----	----	----	----	----	----	----	----
Emmert and Chetek soils, 12 to 18 percent slopes	----	----	----	----	----	----	----	----	----	----	.6	1.0	30	50
Emmert and Chetek soils, 12 to 18 percent slopes, eroded	----	----	----	----	----	----	----	----	----	----	.4	.8	20	40
Emmert and Chetek soils, 18 to 25 percent slopes	----	----	----	----	----	----	----	----	----	----	----	----	----	----
Emmert and Chetek soils, 18 to 25 percent slopes, eroded	----	----	----	----	----	----	----	----	----	----	----	----	----	----
Emmert-Hayden complex, 2 to 6 percent slopes, eroded	40	50	7	9	35	45	----	----	16	18	1.5	2.5	75	125
Emmert-Hayden complex, 6 to 12 percent slopes, eroded	30	40	5	7	25	35	----	----	12	15	1.1	2.1	55	105
Emmert-Hayden complex, 12 to 18 percent slopes, eroded	----	----	----	----	----	----	----	----	----	----	.8	1.6	40	80
Emmert-Hayden complex, 18 to 25 percent slopes, eroded	----	----	----	----	----	----	----	----	----	----	.5	1.1	25	55
Estherville sandy loam, 0 to 2 percent slopes	40	50	7	9	30	40	----	----	17	20	1.8	2.8	90	140
Estherville sandy loam, 0 to 2 percent slopes, wind eroded	35	45	6	8	25	35	----	----	15	18	1.6	2.6	80	130
Estherville sandy loam, 2 to 6 percent slopes	35	45	6	8	25	35	----	----	15	18	1.6	2.6	80	130
Estherville sandy loam, 2 to 6 percent slopes, eroded	30	40	5	7	20	30	----	----	12	15	1.4	2.3	70	115
Estherville sandy loam, 6 to 12 percent slopes	30	40	5	7	20	30	----	----	10	13	1.4	2.3	70	115
Estherville sandy loam, 6 to 12 percent slopes, eroded	25	35	4	6	15	20	----	----	8	11	1.1	2.0	55	100
Fairhaven silt loam, light-colored variant, 0 to 2 percent slopes	50	60	9	11	50	60	----	----	20	25	2.5	3.5	125	175
Fairhaven silt loam, light-colored variant, 2 to 6 percent slopes	45	55	8	10	45	55	----	----	18	23	2.3	3.2	115	160
Hayden fine sandy loam, 0 to 2 percent slopes	60	80	11	14	55	75	----	----	20	25	3.0	4.0	150	200
Hayden fine sandy loam, 2 to 6 percent slopes	55	75	10	14	50	75	----	----	20	25	3.0	4.0	150	200
Hayden fine sandy loam, 2 to 6 percent slopes, moderately eroded	50	75	9	14	45	70	----	----	18	23	2.8	3.8	140	190
Hayden fine sandy loam, 6 to 12 percent slopes	50	70	9	13	45	65	----	----	15	20	2.8	3.6	140	180
Hayden fine sandy loam, 6 to 12 percent slopes, moderately eroded	45	65	8	12	45	60	----	----	14	19	2.5	3.3	125	165
Hayden fine sandy loam, 6 to 12 percent slopes, severely eroded	40	55	7	10	40	50	----	----	----	----	2.0	3.0	100	150
Hayden fine sandy loam, 12 to 18 percent slopes	40	55	7	10	40	50	----	----	----	----	2.2	3.2	110	160
Hayden fine sandy loam, 12 to 18 percent slopes, moderately eroded	35	50	6	9	35	45	----	----	----	----	2.0	3.0	100	150
Hayden fine sandy loam, 12 to 18 percent slopes, severely eroded	----	----	----	----	----	----	----	----	----	----	1.5	2.3	75	115

See footnotes at end of table.

TABLE 2.--ESTIMATED AVERAGE YIELDS PER ACRE OF PRINCIPAL CROPS UNDER TWO LEVELS OF MANAGEMENT--CONTINUED

Soil	Corn for grain		Corn for silage		Oats		Rye		Soybeans		Hay 1/		Rotation pasture 2/	
	A	B	A	B	A	B	A	B	A	B	A	B	A	B
	Bu.	Bu.	Tons	Tons	Bu.	Bu.	Bu.	Bu.	Bu.	Bu.	Tons	Tons	A.U.D. 3/	A.U.D. 3/
Hayden fine sandy loam, 18 to 35 percent slopes	----	----	----	----	----	----	----	----	----	----	1.3	2.0	65	100
Hubbard loamy sand, 0 to 2 percent slopes	30	40	5	7	25	35	15	25	12	17	1.5	2.5	75	125
Hubbard loamy sand, 0 to 2 percent slopes, wind eroded	25	35	5	6	20	30	12	22	10	15	1.3	2.3	65	115
Hubbard loamy sand, 2 to 6 percent slopes	25	35	5	6	20	30	9	18	10	15	1.3	2.3	65	115
Hubbard loamy sand, 2 to 6 percent slopes, eroded	20	30	4	5	15	25	6	15	7	13	1.1	2.1	55	105
Hubbard loamy sand, 2 to 6 percent slopes, severely eroded	----	----	----	----	----	----	----	----	----	----	1.0	2.0	50	100
Hubbard loamy sand, 6 to 12 percent slopes	----	----	----	----	----	----	----	----	----	----	1.1	2.1	55	105
Hubbard loamy sand, 6 to 12 percent slopes, eroded	----	----	----	----	----	----	----	----	----	----	1.0	2.0	50	100
Hubbard loamy sand, 6 to 12 percent slopes, severely eroded	----	----	----	----	----	----	----	----	----	----	----	----	----	----
Hubbard loamy sand, 12 to 25 percent slopes	----	----	----	----	----	----	----	----	----	----	----	----	----	----
Hubbard loamy sand, 12 to 25 percent slopes, eroded	----	----	----	----	----	----	----	----	----	----	----	----	----	----
Hubbard sandy loam, 0 to 2 percent slopes	40	50	7	9	30	40	----	----	17	20	2.0	3.0	100	150
Hubbard sandy loam, 0 to 2 percent slopes, wind eroded	35	45	6	8	25	35	----	----	15	18	1.8	3.0	90	150
Hubbard sandy loam, 2 to 6 percent slopes	35	45	6	8	25	35	----	----	15	18	1.8	3.0	90	150
Hubbard sandy loam, 2 to 6 percent slopes, eroded	30	40	5	7	20	30	----	----	12	15	1.6	2.8	80	140
Hubbard sandy loam, 6 to 12 percent slopes, eroded	25	35	4	6	15	25	----	----	10	13	1.5	2.8	75	140
Isanti loamy fine sand	25	40	4	7	20	35	----	----	9	16	1.0	2.0	50	100
Lino loamy fine sand, 0 to 2 percent slopes	25	50	5	9	25	40	----	----	12	20	1.0	2.5	50	125
Lino loamy fine sand, 0 to 2 percent slopes, wind eroded	20	45	5	8	20	35	----	----	10	18	.8	2.3	40	115
Lino loamy fine sand, 2 to 6 percent slopes	20	45	5	8	20	35	----	----	10	18	.8	2.3	40	115
Lino loamy fine sand, loamy substratum, 0 to 2 percent slopes	30	50	5	9	25	40	----	----	12	20	1.0	2.1	50	105
Loamy wet land	30	45	5	8	30	45	----	----	12	18	1.0	2.0	50	100
Marsh	----	----	----	----	----	----	----	----	----	----	----	----	----	----
Milaca fine sandy loam, 0 to 2 percent slopes	50	70	9	13	50	65	----	----	20	26	2.5	4.0	125	200
Milaca fine sandy loam, 2 to 6 percent slopes	45	65	8	12	45	60	----	----	18	25	2.5	4.0	125	200
Milaca fine sandy loam, 2 to 6 percent slopes, moderately eroded	40	60	7	11	40	55	----	----	17	23	2.3	3.7	115	185
Milaca fine sandy loam, 6 to 12 percent slopes, eroded	35	50	6	9	35	45	----	----	14	19	2.0	3.2	100	160
Milaca fine sandy loam, 12 to 18 percent slopes	30	45	5	8	30	40	----	----	----	----	2.0	3.0	100	150

Milaca fine sandy loam, 18 to 25 percent slopes	----	----	----	----	----	----	----	----	----	----	1.5	2.5	75	125
Mora loam, 0 to 2 percent slopes	50	70	9	13	50	65	----	----	20	26	3.0	4.0	150	200
Mora loam, 2 to 6 percent slopes	45	65	8	12	45	60	----	----	18	25	3.0	4.0	150	200
Peat and muck, deep	35	65	6	12	35	50	----	----	15	25	1.5	3.0	75	150
Peat and muck, shallow, over loam	35	65	6	12	35	50	----	----	15	25	1.5	3.0	75	150
Peat and muck, shallow, over sand	30	55	5	10	30	45	----	----	12	20	1.5	2.5	75	125
Peat-Lino complex	25	45	4	8	15	35	----	----	9	16	1.0	2.0	50	100
Pomroy loamy fine sand, 0 to 2 percent slopes	40	55	7	10	30	40	----	----	15	18	2.0	3.0	100	150
Pomroy loamy fine sand, 2 to 6 percent slopes	35	50	6	9	25	35	----	----	13	16	1.8	2.8	90	140
Ronneby loam, 0 to 2 percent slopes	40	65	8	12	45	60	----	----	18	25	1.5	3.0	75	150
Salida complex, 0 to 6 percent slopes	25	35	5	6	20	25	12	22	10	13	1.0	2.0	50	100
Salida complex, 0 to 6 percent slopes, eroded	20	30	4	5	15	20	8	15	6	8	.8	1.8	40	90
Salida complex, 6 to 12 percent slopes	----	----	----	----	----	----	----	----	----	----	.8	1.8	40	90
Salida complex, 6 to 12 percent slopes, eroded	----	----	----	----	----	----	----	----	----	----	.6	1.5	30	75
Salida complex, 12 to 25 percent slopes	----	----	----	----	----	----	----	----	----	----	----	----	----	----
Wadena loam, 0 to 2 percent slopes	50	60	9	11	50	60	----	----	20	25	2.5	3.5	125	175
Zimmerman loamy fine sand, 0 to 2 percent slopes	30	45	5	8	25	35	15	25	13	17	1.5	2.5	75	125
Zimmerman loamy fine sand, 0 to 2 percent slopes, wind eroded	25	40	5	7	20	30	10	20	11	15	1.3	2.3	65	115
Zimmerman loamy fine sand, 2 to 6 percent slopes	25	40	5	7	20	30	8	17	11	15	1.3	2.3	65	115
Zimmerman loamy fine sand, 2 to 6 percent slopes, eroded	20	35	4	6	15	25	6	14	9	13	1.1	2.1	55	105
Zimmerman loamy fine sand, 6 to 12 percent slopes	----	----	----	----	----	----	----	----	----	----	1.1	2.1	55	105
Zimmerman loamy fine sand, 6 to 12 percent slopes, eroded	----	----	----	----	----	----	----	----	----	----	1.0	2.0	50	100
Zimmerman fine sand, 12 to 25 percent slopes	----	----	----	----	----	----	----	----	----	----	----	----	----	----

1/ Estimates are for alfalfa or alfalfa-brome mixtures. Yields of red clover-alsike clover-timothy mixtures are 10 to 15 percent less. Adolph soils, Isanti soils, the Lino units, Loamy wet land, the Peat and muck units, and the Peat-Lino complex are not suitable for alfalfa-brome mixtures, and the estimates given are for red clover-alsike clover-timothy mixtures.

2/ Estimates are for grass-legume mixtures.

3/ Animal-unit-days. An animal-unit-day is the amount of pasture consumed in 1 day by one animal unit (one cow, one horse, or seven sheep). An estimate of 125 indicates that 1 acre will provide grazing for one animal unit for 125 days.

TABLE 3.--EXPECTED YIELDS OF PINE ON SOILS OF SPECIFIED SITE INDEXES

[Data are for fully stocked, unmanaged, native stands. Yields from managed plantations of red pine could be 150 percent of those from unmanaged stands]

Site index	Age	Total volume	Merchantable volume	
	Yr.	Cu. ft./acre	Cu. ft./acre	Cords/acre
Red pine				
60	50	4,850	4,000	44.0
	60	5,400	4,500	50.0
	70	6,000	5,200	57.8
	80	6,200	5,400	60.0
70	50	6,000	5,200	57.8
	60	6,400	5,600	62.2
	70	6,800	6,000	66.7
	80	7,200	6,400	71.1
White pine				
70	50	5,600	4,900	54.4
	60	6,400	5,700	63.3
	70	7,200	6,500	72.2
	80	7,800	7,200	80.0
80	50	6,400	5,700	63.3
	60	7,200	6,500	72.2
	70	7,800	7,200	80.0
	80	8,800	8,100	90.0
Jack pine				
60	50	3,250	2,880	32.0
	60	3,600	3,200	35.5
	70	3,800	3,400	37.8
	80	3,850	3,450	38.3
70	50	3,830	3,420	38.0
	60	3,900	3,550	39.4
	70	4,000	3,600	40.0
	80	4,200	3,800	42.3

The equipment limitation is *slight* if there are no restrictions on the type of equipment or on the time of year that the equipment can be used. The slope generally is less than 20 percent. The limitation is *moderate* if the slope is between 20 and 50 percent; if the use of equipment is restricted by stones or other obstructions, by seasonal wetness that lasts no more than 3 months, or by instability or other unfavorable soil characteristics; or if the use of equipment damages tree roots to some extent. The limitation is *severe* if the slope is more than 50 percent; if the use of equipment is severely restricted by stones or major obstructions or by wetness that lasts more than 3 months; or if the use of equipment causes severe damage to tree roots or soil structure.

The hazard of insects and disease is *slight* if no damage to the wood crop is expected from these sources. It is *moderate* if some loss is expected. It is *severe* if considerable loss is expected and control measures are needed. The damage caused by pocket gophers, the most damaging pest in Sherburne County, is most severe on sandy soils.

The windthrow hazard, or the danger of trees being blown over by the wind, is *slight* if roots extend to a considerable depth, so that individual trees are stable during high winds. The hazard is *moderate* if trees are stable except during periods of excessive wetness and high winds. It is *severe* if root development is restricted and individual trees are unstable during periods of wetness and moderate or high winds.

The erosion hazard is the degree of potential loss of soil by wind or water. The hazard is *slight* if erosion is no problem. It is *moderate* if measures are needed to prevent unnecessary loss of soil. It is *severe* if special equipment and special methods of operation are needed to minimize loss and deterioration of the soil.

Woodland group 1

This group consists of deep, nearly level to steep, excessively drained, droughty soils of the outwash plain. Runoff is medium, permeability is rapid, and internal drainage is rapid. Large open areas are highly susceptible to wind erosion. There are some blowouts.

The soils in this group are low producers of native hardwoods. Bur oak and northern pin oak are the most common species. For both of these, the site index is about 30. The trees have very poor form and are of very poor quality.

These soils are high producers of pine. If they are to be managed as woodland, it is advisable to replace the oak with red pine or jack pine, preferably red pine (fig. 13). For red pine, the average site index is 58. For jack pine, the average site index is 60, but jack pine, although it grows well, is of poorer quality than red pine and is a favored host to some serious insect pests. It is advisable to harvest either species for pulp and small wood products between the ages of 40 and 50. Red pine can be harvested for larger products at about age 80. This species should be replanted after the harvest cut, because natural reseeding is unlikely.

Figure 13.—**Year-old stand of red pine on Zimmerman loamy fine sand.**

Scotch pine should be planted for Christmas-tree (fig. 14) production only. It grows well for a few years but then becomes susceptible to insects and disease. White spruce is suitable for borders or for interspersed wildlife areas but not for solid forest plantations. Redcedar is suitable for wildlife clump plantings in sunny locations.

Seedling mortality is slight on level sites and on cool northern and eastern slopes. It is moderate on warm southern and western slopes. More seedlings survive if heavy, high-quality nursery stock is planted.

Plant competition is slight or moderate, depending largely on site preparation. For a forest plantation, site preparation includes scalping of the sod. A scalper can be attached to the tree-planting machine. Steep slopes should be scalped on the contour. Some of the steeper slopes must be scalped by hand. For windbreak plantings, it is advisable to plow the site and then keep it fallow for one full season before planting. Overhead competition from scrub oak and brush that shade 50 percent or more of the area may necessitate the use of chemical sprays before planting.

The equipment limitation is slight on level sites and gentle slopes and is severe on steep slopes.

The hazard of insects and diseases is slight for red pine, moderate for jack pine, and severe for Scotch pine.

The windthrow hazard is only slight.

The hazard of both wind and water erosion is moderate or severe on steep slopes. The hazard of wind erosion is moderate or severe even on level sites. Field windbreaks of red pine or jack pine are needed. Red pine is preferable. Farmland windbreaks need to be planned for each farm.

Woodland group 2

This group consists of nearly level to rolling, somewhat excessively drained soils that are underlain by gravel at a depth of 18 to 36 inches. Runoff is medium, permeability is rapid or very rapid, and internal drainage is rapid.

The soils in this group are medium producers of red pine and white pine. For red pine, the average site index is 60. For white pine, the average site index is 55.

These soils are used extensively for crops, and only odd and inaccessible areas should be considered for tree planting. The preferred species for planting are red pine, jack pine, and white pine. Red pine and jack pine can be harvested for pulp and small wood products between the ages of 40 and 50. Red pine and white pine can be harvested for timber between the ages of 70 and 80. All three species should be replanted after harvest, because natural reseeding is unlikely.

Figure 14.—Christmas-tree farm on Zimmerman loamy fine sand. This soil is in woodland group 1.

Christmas-tree plantations, field and farmstead windbreaks, and plantings for wildlife are more suitable for these soils than forest plantings. Scotch pine should be planted for Christmas-tree production only. It becomes susceptible to several serious insect pests if allowed to grow beyond Christmas-tree size. Both red pine and jack pine are suitable for field windbreaks. Red pine is preferable. Redcedar is suitable for borders and for wildlife clump plantings in sunny locations. White spruce also is suitable for such plantings. This species tolerates some shade.

Seedling mortality is slight if high-quality stock is planted.

Plant competition generally is moderate. Scalping of the sod is essential in areas where competition is severe. A scalper can be attached to the tree-planting machine. Slopes should be scalped on the contour.

The equipment limitation is slight, and the windthrow hazard is slight.

The hazard of insects and diseases is slight for red pine, slight or moderate for white pine, and moderate or severe for Scotch pine. Blister rust is a moderate hazard for white pine.

The erosion hazard is slight, except in large open areas. Field windbreaks are advisable.

Woodland group 3

This group consists of nearly level to very steep, excessively drained, droughty soils that are underlain by gravel at a depth of 12 to 24 inches. Runoff is medium on the lower slopes but rapid on the steep slopes. Permeability is very rapid, and internal drainage is very rapid.

The soils in this group are low producers of hardwoods; the average site index is 40. Red oak, white oak, and aspen are the most common species. The oak generally is of only fair quality. There are a few maples and elm.

These soils are medium producers of jack pine, red pine, and white pine. For jack pine, the average site index is 60; for red pine, it is 58; and for white pine, 56. If these soils are to be managed as woodland, it would be advisable to plant white pine on the cooler, northern and eastern slopes; jack pine on the warmest, steepest, most severely eroded slopes; and red pine on the most favorable sites—the southern and western slopes. Red pine and jack pine can be harvested for pulp between the ages of 40 and 50 years. Red pine and white pine can be harvested for larger products between the ages of 70 and 80. Replanting generally is needed after the harvest cut. Natural reseeding of white pine may be moderately successful, but natural reseeding of red pine and jack pine is unlikely.

Scotch pine should be planted for Christmas-tree production only. If it grows beyond Christmas-tree size,

the insect hazard is likely to be severe. White spruce tolerates some shade and is suitable for borders and for interspersed wildlife areas. Redcedar is suitable for wildlife plantings in sunny locations.

Seedling mortality is slight on the northern and eastern slopes and moderate on the southern and western slopes, if high-quality nursery stock is planted.

Plant competition is slight or moderate. Scalping to eliminate competing vegetation is essential in some areas. Some of the steeper slopes must be scalped by hand. A scalper attached to the tree-planting machine can be used on lesser slopes. On eroded slopes and hill crests, competition may be so slight as to eliminate the need for scalping. Overhead competition from brush and trees may necessitate the use of chemical sprays before planting.

The equipment limitation is severe.

The hazard of insects and diseases is slight or moderate for all three kinds of native pine. Blister rust is a moderate hazard for white pine.

The windthrow hazard is slight.

The hazard of water erosion is slight to severe. Some of the steeper slopes are seriously eroded. The hazard of wind erosion is moderate or severe unless adequate cover is maintained. Because of the slope, there are few locations suitable for windbreaks. Roads and trails should be built across the slope if possible. Except as necessary for planting and harvesting, the sites should not be disturbed.

Woodland group 4

This group consists of level or undulating, well-drained soils that are underlain by sand and gravel at a depth of 24 to 36 inches. Runoff is medium, permeability is moderate, and internal drainage is medium.

The soils in this group are highly productive agricultural soils and should not be considered for forest plantings. Field windbreaks would be desirable, mainly to keep an even distribution of snow on the ground in winter and to retard hot, dry winds in summer. Odd areas can be planted to vegetation that will attract wildlife.

Woodland group 5

This group consists of nearly level to steep, well drained or moderately well drained soils that are underlain by till or by bands of lacustrine material at a depth of 18 to 48 inches. Runoff is medium, permeability is moderately rapid, and internal drainage is rapid or medium, depending on the depth to the till or the lacustrine material.

The soils in this group are low to medium producers of native hardwoods. For native oak, mainly red oak, the site index is 55 or less. The trees generally have poor form and are of poor quality.

These soils are high producers of pine, particularly red pine and white pine. If they are to be managed as woodland, it is advisable to plant white pine on the northern and eastern slopes and red pine on the southern and western slopes. For red pine, the average site index is 65. For white pine, the average site index is 60. Red pine can be harvested for posts, poles, and pulpwood at the age of 50. Both species can be harvested for larger wood products near the age of 80. Natural reseeding of white pine can be expected after the harvest cut, but natural reseeding of red pine is unlikely.

Scotch pine should be planted for Christmas-tree production only. Redcedar and white spruce are suitable for borders or for interspersed wildlife areas, but not for solid forest plantations. White spruce tolerates some shade. Redcedar requires sunny locations.

If high-quality nursery stock is planted, seedling mortality is slight on the cooler, northern and eastern slopes and slight to moderate on the warmer, southern and western slopes.

Plant competition is slight or moderate. Scalping of the sod to remove competing vegetation is essential before planting. A scalper can be attached to the tree-planting machine for use on the more gentle slopes. The steep slopes must be scalped by hand. Overtopping of the pine by native deciduous trees and shrubs must be controlled.

The equipment limitation is slight on gentle slopes but severe on steep slopes.

Insects and diseases are a slight or moderate hazard. White pine is susceptible to blister rust, but the hazard is not too serious in this county.

The windthrow hazard is slight.

The hazard of water and wind erosion is moderate or severe on the steeper slopes. The hazard of wind erosion is severe, even on level sites. Because of the erosion hazard, scalping should be limited to areas just large enough to accomodate the trees to be planted. Roads and trails should be built across the slope, so they will not encourage gully erosion. Field windbreaks of red pine or jack pine are needed. Red pine is preferable. Robusta poplar, Siberian elm, purple-osier willow, and honeysuckle also are suitable for field windbreaks. Farmstead windbreaks have to be planned for the individual farm.

Woodland group 6

This group consists of nearly level to rolling, well drained or moderately well drained soils that are underlain by till or by a mixture of till and gravel. Runoff is medium, permeability is moderate, and internal drainage is medium.

The soils in this group support mixed stands of northern hardwoods. Basswood, red oak, aspen, and hard maple are the most common species. The trees are of medium to good quality. For aspen, the average site index is 70. For the rest, the average site index is 60. Hard maple is highly competitive because the seedlings are tolerant of shade, but it should not be favored unless the woodland is managed for maple-sugar production. All of these hardwoods can be harvested for lumber and veneer at age 100 or more. Existing stands should be managed for continued production.

For planting, red pine and white pine should be preferred to hardwoods, because the pine produces a larger yield in a shorter time. For red pine, which is the most suitable species, the average site index is 65. Red pine grows best in a sunny location. It is windfirm, moderately fast growing, relatively free from defects, and susceptible to few insects and diseases. It can be harvested for posts, poles, and other small wood products between the ages of 40 and 50, and for larger products between the ages of 70 and 80. For white pine, which is also

excellent for planting but is moderately susceptible to disease, the average site index is 63. White pine can be harvested for large wood products between the ages of 70 and 80. It tolerates some shade and should be preferred for the cooler, better drained sites. Jack pine is an inferior species for these high-quality sites.

Scotch pine should be planted for Christmas-tree production only. White spruce, redcedar, and white-cedar are suitable for interspersed wildlife areas. White-cedar is moderately tolerant of shade and needs a good supply of moisture. White spruce is slightly tolerant of shade. Redcedar grows best in full sunlight.

Seedling mortality is slight for hard maple and moderate or severe for other hardwoods. It is moderate for white pine, and moderate or severe for red pine.

Plant competition is moderate or severe. Site preparation is needed Overhead competition may necessitate the use of chemical sprays before planting.

Except in spring and after heavy rains, the equipment limitation is slight. The hazard of insects and diseases is slight, and the windthrow hazard is slight.

The erosion hazard is moderate on the stronger slopes and slight elsewhere. Site preparation should be confined to areas where trees are to be planted. Roads and trails should be constructed across the slope. Field windbreaks are beneficial but are not essential for control of wind erosion.

Woodland group 7

This group consists of hilly to very steep, well-drained soils that are underlain by till or by a mixture of till and gravel. Runoff is rapid or very rapid, permeability is moderate, and internal drainage is medium.

The soils in this group support mixed stands of northern hardwoods. Basswood, hard maple, red oak, and white oak are the principal species. On the warmer, southern and western slopes, the trees are of medium quality. On the northern and eastern slopes, the trees are of good quality. For the southern slopes, the average site index is 45. For the northern slopes, the average site index is 55. The hardwoods on these soils can be harvested for posts, ties, veneer, and lumber. Existing stands that are in good condition should be managed for continued production of hardwoods. If a stand is overgrazed, overcut, or generally deteriorated, it would be advisable to replace the hardwoods with red pine and white pine. Both species of pine can be harvested for logs between the ages of 75 and 90. Red pine can be harvested for posts, pulp, and small poles at the age of about 50. For red pine, the average site index is 55.

Scotch pine should be planted for Christmas-tree production only. White spruce and white-cedar are suitable for interspersed wildlife areas. Both should be planted on northern and eastern slopes. Redcedar is suitable for wildlife areas on southern and western slopes.

Seedling mortality is slight for hard maple and moderate or severe for other hardwoods. It is moderate for white pine and moderate or severe for red pine.

Plant competition is moderate or severe. Site preparation is needed.

The equipment limitation is moderate or severe, depending on the gradient. Some slopes are too steep to be safe for equipment.

The hazard of insects and diseases is slight, and the windthrow hazard is slight.

The erosion hazard is severe. A cover of vegetation should be maintained, and site preparation should be confined to areas where trees are to be planted. Field and farm windbreaks generally are not needed on these steep slopes.

Woodland group 8

This group consists of slightly depressional to nearly level soils that are somewhat poorly drained or poorly drained. These soils are underlain by till. Runoff is slow, permeability is moderately slow, and internal drainage is slow or very slow.

The soils in this group are medium to high producers of wetland hardwoods. Soft maple, ash, poplar, and elm are the most common species. Either robusta poplar or native cottonwood is probably the most suitable species. Robusta poplar provides very high yields of good-quality wood in short rotations and is preferable to native cottonwood because of its resistance to leaf rust. It is the species preferable for planting. White-cedar is a preferred evergreen for interspersed wildlife areas.

Seedling mortality is slight to severe in depressed areas that are sometimes flooded. For planted poplars, seedling mortality is slight.

Plant competition from lowland brush is moderate or severe. The equipment limitation is slight or moderate. The hazard of insects and diseases is slight.

The windthrow hazard is likely to be severe because of shallow rooting.

There is no erosion hazard. Field and farmstead windbreaks are seldom needed. The species most suitable for windbreaks are poplar, willow, and white-cedar. Green ash and soft maple should be considered also.

Woodland group 9

This group consists of somewhat poorly drained to very poorly drained soils that are subject to flooding and generally have a high water table. These soils may be covered with water for several weeks at a time. For the most part, they are nearly level to slightly depressional, but in spots they are undulating. Runoff is slow, permeability is rapid or moderately rapid, and internal drainage is rapid or medium.

The soils in this group are fairly high producers of hardwoods. Cottonwood, aspen, and oak are the most common species. Site index figures are not available. If these soils are to be managed as woodland, it would be advisable to favor or to plant cottonwood or hybrid poplar. The rate of growth is good, production is high, and the wood is easy to use. White-cedar is suitable for borders and for wildlife clump plantings.

Seedling mortality is severe for naturally occurring oak and aspen, and slight or moderate for native cottonwoods. For planted cottonwoods and other poplars, seedling mortality is slight. Cottonwood should be replanted if it does not reseed after harvest.

Plant competition from dogwood, alder, sumac, and other native brush is likely to be moderate or severe. Scalping before planting is generally not needed, because

cottonwood seedlings grow vigorously if there is no overhead shade. Sod is not a serious problem.

The equipment limitation is slight in winter but is likely to be moderate in spring and after heavy rains.

The hazard of insects and diseases is slight. Leaf rust is a severe hazard to native cottonwood.

The windthrow hazard is moderate or severe.

The erosion hazard is slight. Field windbreaks are not needed. Poplar, willow, and white-cedar are suitable for use in farmstead windbreaks.

Woodland group 10

This group consists of organic soils that are deep to shallow over sand or loam. The only purpose in planting trees on these soils is to protect crops and to keep snow evenly distributed. Willow, poplar, and white-cedar are suitable species for field windbreaks. Willow and poplar are preferable.

Woodland group 11

This group consists mainly of wet, depressional soils that are covered with water most of the growing season. These soils have little or no runoff and are too poorly drained to be suitable for woodland. They generally support cattails, marsh grasses, or other aquatic vegetation.

Windbreaks

Field windbreaks are of major importance in this county, because many of the soils are highly susceptible to wind erosion. Windbreaks do not give complete protection, but along with good management practices, they are effective in keeping snow evenly distributed in winter and in retarding hot, dry winds in summer.

Pine, mainly red pine, is the most suitable and the most effective species for field windbreaks. Deciduous trees and shrubs, ordinarily considered to be the most effective because they permit wind to filter through, are not well suited to the soils of this county. Siberian elm, Norway poplar, robusta poplar, purple-osier willow, lilac, and honeysuckle can be used, particularly in depressions where moisture is plentiful and in areas where the water table is high.

Field windbreaks should be planted in a series across the landscape. Single rows of red pine at intervals of no more than 40 rods are satisfactory. Rows at intervals of less than 40 rods, even as little as 20 rods, are even more effective.

Wildlife and Recreation

Sherburne County is generally poor in wildlife resources, compared with other parts of Minnesota. The low fertility of the soils and the nature and distribution of cover make it unlikely that the needs of a large wildlife population could be met.

The entire county is rated poor as pheasant range by the Minnesota Conservation Department. The potential for development of pheasant habitat is low. The soils are not well suited to the production of corn, which is a preferred food of pheasants, and about 25 percent of the county is woodland, though pheasants prefer open land. Pheasants are most likely to be found on the soils of associations 3 and 4, but even there the number is small.

The southern two-thirds of the county, mainly the Zimmerman-Lino-Isanti-peat association and the Hubbard-Estherville-Salida association, is fairly heavily used by migrating waterfowl (fig. 15). Although wetland areas are common in these parts of the county, waterfowl production is only moderate as compared with that in the prime waterfowl areas of west-central Minnesota.

Figure 15.—**Teal ducks in a pothole on the Hubbard-Estherville-Salida association.**

Deer are hunted in the woodlands on all associations. The woodlands are readily accessible, but the soils are not fertile enough to support a large number of deer.

Nearly all the kinds of fish caught in Minnesota can be found in Sherburne County. Northern pike, walleyed pike, and pan fish, such as sunfish and crappie, are the kinds most sought after. The Mississippi River and several lakes on the Hubbard-Estherville-Salida association are among the more productive bodies of water in the State.

Approximately 31,000 acres of the Zimmerman-Lino-Isanti-peat association is being developed as a national wildlife refuge by the Bureau of Sport Fisheries and Wildlife, U.S. Department of Interior. This refuge will be on the St. Francis River, just south and east of Santiago. More than 10,000 acres of lowlands will be flooded and managed for the propagation of waterfowl and other wetland wildlife.

There are many opportunities for recreational development in Sherburne County. Many areas along the Mississippi, Elk, and St. Francis Rivers and along some of the lakes are suitable for picnic sites, resorts for tourists, and overnight camping sites. Many of these areas also are suitable for golf courses, hiking or riding trails, and ski runs. Several sites in the rough moraines north of Elk River, on the Hayden-Braham-Emmert association and the Burkhardt-Chetek-Emmert association, have excellent potential for ski runs.

Engineering Applications [1]

Some soil properties are of special interest to engineers because they affect the construction and maintenance of roads, airports, pipelines, building foundations, facilities for water storage, erosion control structures, drainage systems, and sewage disposal systems. The properties most important to engineers are permeability, shear strength, compaction characteristics, drainage, shrink-swell characteristics, grain size, plasticity, and reaction. Depth to the water table, depth to bedrock, and relief also are important.

The information in this survey can be used to—

1. Make soil and land use studies that will aid in selecting and developing industrial, business, residential, and recreational sites.
2. Make preliminary estimates of the soil properties that affect the planning of irrigation systems, farm ponds, agricultural drainage systems, and other structures for conservation of soil and water.
3. Make preliminary evaluations that will aid in selecting locations for highways, airports, pipelines, and cables and in planning detailed investigations at the selected locations.
4. Locate probable sources of sand and gravel and other construction material.
5. Correlate performance of engineering structures with soil mapping units to develop information that will be useful in planning engineering practices and in designing and maintaining engineering structures.
6. Determine the suitability of soils for cross-country movement of vehicles and construction equipment.
7. Supplement the information obtained from other published maps and reports and from aerial photographs to make maps and reports that can be used readily by engineers.
8. Develop other preliminary estimates for construction purposes.

With the soil map for identification of soil areas, the engineering interpretations reported here can be useful for many purposes. It should be emphasized that these interpretations may not eliminate the need for sampling and testing at the site of specific engineering works involving heavy loads and where the excavations are deeper than the depths of layers here reported. Even in these situations, the soil map is useful for planning more detailed field investigations and for suggesting the kinds of problems that may be expected.

Additional information on the properties of soils can be found in the profile descriptions in the sections "General Soil Map" and "Formation and Classification of the Soils."

Some of the terms used by soil scientists may have a special meaning in soil science and may be unfamiliar to or have a different meaning to engineers. These terms are defined in the Glossary in the back of this publication.

[1] ROSS A. ST. JOHN, State conservation engineer, SCS, helped prepare this section.

Engineering Classification Systems

Two systems of classifying soils for engineering purposes are in general use: the AASHO system and the Unified system.

Most highway engineers classify soil material in accordance with the system approved by the American Association of State Highway Officials (AASHO) (*1*, *7*).[2] In this system all soil material is classified in seven principal groups. The classification is based on mechanical analysis and plasticity test data. The groups range from A–1, which consists of soils that have the highest bearing capacity and are the best for subgrade, to A–7, which consists of soils that have the lowest strength when wet and are the poorest for subgrade.

Some engineers prefer to use the Unified soil classification system (*7*, *9*). This system is based on identification of soils according to their texture and plasticity and their performance as engineering construction material.

The estimated classifications for the soils in Sherburne County are given in table 4.

Engineering Interpretations

The estimated properties that are significant in engineering are listed in table 4.

Estimates of the suitability of the soils for various engineering uses are given in table 5. Specific features that are likely to affect the selection, design, and application of various engineering practices were considered, and evaluations were based on test data and field performance.

A soil feature favorable for one engineering use is likely to be unfavorable for another. For example, a rapidly permeable substratum would make a soil unsuitable as a site for a farm pond but would make it suitable for an artificial drainage system.

If 10 percent or more of the soil material can pass through a number 200 sieve, the soil is susceptible to damaging frost action. Frost heaving occurs if there are differences in expansion between one material and another. Some deposits of glacial till contain lenses or pockets of fine sand and silt and consequently are susceptible to differential frost heaving. If a highway is laid over glacial till, the subgrade material should contain a layer of material that is not susceptible to damaging frost heaving.

Some soils that have a high water table can be made more suitable for borrow and roadway excavation by constructing drainage ditches before the earthwork is started. Underdrains are essential where the soil is unstable because of a perched water table or a normally high water table.

Formation and Classification of the Soils

This section describes the factors that are involved in soil formation. It also describes the outstanding characteristics of the soils of Sherburne County, relates these characteristics to the factors of soil formation, and shows how the soils of this county have been classified according to the two systems of classification used in the United States.

[2] Italic numbers in parentheses refer to Literature Cited, p. 80.

TABLE 4.--ESTIMATED

Soil series and map symbols	Depth to water table	Depth from surface	Classification	
			USDA texture	Unified
	Ft.	In.		
Adolph (Ap) 1/	3+	0 to 12	Loam	CL
		12 to 19	Loam	CL
		19 to 40	Sandy loam	SM-SC
		40 to 48	Sandy loam	SM-SC
Alluvial land (Ad, Af)	(2/)	(2/)	(2/)	(2/)
Beach sand (Ba)	1 to 10	0 to 60	Sand	SP
Becker (BeA, BeB)	10+	0 to 34	Very fine sandy loam.	SM
		34 to 48	Loamy fine sand or sand and gravel.	SP-SM or GW.
Braham (BrA, BrB, BrB2, BrC, BrC2, BrD)	6 to 10+	0 to 8	Loamy fine sand	SP-SM
		8 to 29	Fine sand	SP-SM
		29 to 54	Silty clay loam	CL
Burkhardt (BuA, BuB, BuB2)	10+	0 to 22	Sandy loam	SC
		22 to 36	Sand and gravel	GW
Chetek (ChA, ChB, ChB2, ChC, ChC2, ChC3)	10+	0 to 23	Sandy loam	SC
		23 to 48	Gravel and sand	GW
Dundas (Du)	4 to 8	0 to 19	Loam	ML
		19 to 32	Clay loam	CL
		32 to 42	Clay loam	ML or CL.
Emmert:				
Gravelly loamy sands (EgC, EgE)	10+	0 to 6	Gravelly loamy sand.	SP-SM
		6 to 48	Gravel	GW
Loamy sands (ElA, ElB, ElB2, ElC, ElC2, ElC3, EmD, EmD2, EmE, EmE2, ErB2, ErC2, ErD2, ErE2). (For properties of Chetek soils in mapping units EmD, EmD2, EmE, and EmE2, refer to Chetek soils. For properties of Hayden soils in mapping units ErB2, ErC2, ErD2, and ErE2, refer to Hayden soils.)	10+	0 to 18	Loamy sand	SM
		18 to 48	Sand and gravel	SP or GP.
Estherville (EsA, EsA2, EsB, EsB2, EsC, EsC2)	10+	0 to 22	Sandy loam	SM
		22 to 60	Mixed sand and gravel.	GW-GM
Fairhaven (FaA, FaB)	10+	0 to 35	Silt loam	ML
		35 to 54	Fine sand	SP-SM

See footnotes at end of table.

PROPERTIES

Classification--continued	Percentage passing sieve--			Permeability	Available water capacity	Reaction	Shrink-swell potential
AASHO	No. 4 (4.7 mm.)	No. 10 (2.0 mm.)	No. 200 (0.074 mm.)	In./hr.	In./in. of soil	pH	
A-6	85 to 95	80 to 90	50 to 60	0.63 to 2.00	0.21	6.6 to 7.3	Medium.
A-6	85 to 95	80 to 90	50 to 60	0.63 to 2.00	0.21	6.1 to 6.5	Medium.
A-2 or A-4	85 to 90	75 to 85	25 to 50	0.20 to 0.63	0.10	6.6 to 7.3	Low.
A-2 or A-4	85 to 90	75 to 85	25 to 50	0.20 to 0.63	0.10	6.6 to 7.3	Low.
(2/)	(2/)	(2/)	(2/)	(2/)	(2/)	(2/)	(2/).
A-3	100	100	2 to 5	> 6.30	0.02	(3/)	Low.
A-2	100	95 to 100	25 to 35	0.63 to 2.00	0.21	6.6 to 7.3	Low.
A-3 or A-1	40 to 100	30 to 100	2 to 10	> 6.30	0.02	6.6 to 7.3	Low.
A-2	100	100	10 to 15	> 6.30	0.07	5.1 to 5.5	Low.
A-2	100	100	5 to 12	> 6.30	0.03	5.6 to 6.0	Low.
A-7	100	95 to 100	80 to 90	0.20 to 0.63	0.17	6.1 to 6.5	Medium.
A-2	85	80 to 90	25 to 35	2.00 to 6.30	0.13	5.1 to 5.5	Low.
A-1	30 to 40	20 to 30	2 to 5	> 6.30	0.02	5.6 to 6.0	Low.
A-2	80 to 90	80 to 90	25 to 35	2.00 to 6.30	0.10	2.6 to 6.0	Low.
A-1	30 to 40	20 to 30	2 to 5	> 6.30	0.02	5.6 to 6.0	Low.
A-4	100	100	75 to 85	0.63 to 2.00	0.18	6.1 to 6.5	Medium.
A-4 or A-6	90 to 100	90 to 100	60 to 85	0.20 to 0.63	0.17	6.1 to 6.5	Medium.
A-4 or A-6	90 to 100	90 to 100	60 to 80	0.20 to 0.63	0.17	7.9 to 8.4	Medium.
A-1	50 to 75	60 to 80	5 to 10	>6.30	0.05	5.1 to 5.5	Low.
A-1	30 to 40	5 to 10	2 to 5	>6.30	0.02	5.1 to 5.5	Low.
A-2	95 to 100	80 to 100	15 to 20	>6.30	0.05	5.1 to 5.5	Low.
A-1	40 to 80	30 to 50	2 to 5	>6.30	0.02	5.6 to 6.0	Low.
A-2	90 to 100	90 to 100	30 to 35	2.00 to 6.30	0.13	5.6 to 6.0	Low.
A-2	40 to 50	30 to 40	5 to 10	>6.30	0.02	7.9 to 8.4	Low.
A-4	100	100	75 to 85	0.63 to 2.00	0.18	6.6 to 7.3	Medium.
A-2	50 to 90	30 to 50	5 to 12	>6.30	0.03	7.9 to 8.4	Low.

TABLE 4.--ESTIMATED

Soil series and map symbols	Depth to water table	Depth from surface	Classification	
			USDA texture	Unified
	Ft.	In.		
Hayden (HaA, HaB, HaB2, HaC, HaC2, HaC3, HaD, HaD2, HaD3, HaE).	10+	0 to 19	Fine sandy loam----	SM or ML.
		19 to 41	Clay loam----------	CL------
		41 to 51	Loam to clay loam--	ML or CL.
Hubbard:				
Loamy sands (HuA, HuA2, HuB, HuB2, HuB3, HuC, HuC2, HuC3, HuE, HuE2).	10+	0 to 23	Loamy sand---------	SP-SM---
		23 to 60	Sand---------------	SP------
		60 to 80	Sand---------------	SP------
Sandy loams (HyA, HyA2, HyB, HyB2, HyC2)------	10+	0 to 20	Sandy loam---------	SM------
		20 to 54	Sand---------------	SP------
		54 to 65	Gravelly coarse sand.	GW-GM---
Isanti (Is)----------	0 to 2	0 to 11	Mucky loamy fine sand.	Pt------
		11 to 36	Fine sand----------	SP-SM---
		36 to 48	Sand---------------	SP-SM---
Lino:				
Loamy fine sands (LnA, LnA2, LnB)----------	4+	0 to 7	Loamy fine sand----	SP-SM---
		7 to 48	Fine sand----------	SP-SM---
Loamy fine sand, loamy substratum (LsA)-------	4+	0 to 6	Fine sandy loam----	SM------
		6 to 15	Loamy fine sand----	SP-SM---
		15 to 40	Fine sand----------	SP-SM---
		40 to 60	Stratified fine sands and loams.	SM or ML.
Loamy wet land (Lw)----------	1 to 4	(2/)	(2/)----------	(2/)----
Marsh (Ma)----------	0	(2/)	(2/)----------	(2/)----
Milaca (MfA, MfB, MfB2, MfC2, MfD, MfE)----------	10+	0 to 7	Fine sandy loam----	SM------
		7 to 19	Fine sandy loam----	SM or SC.
		19 to 60	Sandy loam---------	SM or SC.
Mora (MoA, MoB)----------	10+	0 to 5	Loam---------------	ML------
		5 to 16	Sandy loam---------	SC-SM---
		16 to 30	Sandy loam---------	SC-SM---
		30 to 42	Sandy loam---------	SC-SM---
Peat and muck (Pa, Pc, Pd)----------	0	(2/)	(2/)----------	Pt------
Peat-Lino complex (Pn)----------	2+	(2/)	(2/)----------	(2/)----

See footnotes at end of table.

PROPERTIES--CONTINUED

Classification--continued	Percentage passing sieve--			Permeability	Available water capacity	Reaction	Shrink-swell potential
AASHO	No. 4 (4.7 mm.)	No. 10 (2.0 mm.)	No. 200 (0.074 mm.)				
				In./hr.	In./in. of soil	pH	
A-4----------	90 to 100	90 to 100	36 to 60	2.00 to 6.30	0.13	6.1 to 6.5	Low.
A-4 or A-6------	90 to 100	90 to 100	60 to 85	0.20 to 0.63	0.17	6.1 to 6.5	Medium.
A-4 or A-6------	90 to 100	90 to 100	60 to 80	0.20 to 0.63	0.17	7.9 to 8.4	Medium.
A-2----------	95 to 100	95 to 100	10 to 15	>6.30	0.07	5.6 to 6.0	Low.
A-2----------	75 to 90	70 to 90	2 to 5	>6.30	0.03	6.1 to 6.5	Low.
A-2----------	75 to 90	70 to 90	2 to 5	>6.30	0.30	7.4 to 7.8	Low.
A-2----------	95 to 100	90 to 100	25 to 35	2.00 to 6.30	0.13	5.6 to 6.0	Low.
A-2----------	75 to 90	70 to 90	2 to 5	>6.30	0.03	5.1 to 5.5	Low.
A-1----------	40 to 50	35 to 45	5 to 10	>6.30	0.03	7.4 to 7.8	Low.
A-8----------	100	100	10 to 15	2.00 to 6.30	0.10	5.1 to 5.5	Low.
A-2----------	100	100	10 to 15	>6.30	0.03	5.6 to 6.0	Low.
A-2----------	100	100	10 to 15	>6.30	0.03	5.1 to 6.0	Low.
A-2----------	100	100	10 to 15	>6.30	0.07	5.1 to 5.5	Low.
A-2----------	100	100	10 to 15	>6.30	0.03	5.6 to 6.0	Low.
A-2----------	100	100	15 to 35	2.00 to 6.30	0.17	6.1 to 6.5	Low.
A-2----------	100	100	10 to 15	>6.30	0.05	6.6 to 7.3	Low.
A-2----------	100	100	10 to 15	>6.30	0.03	6.6 to 7.3	Low.
A-2 or A-4------	100	100	15 to 60	0.20 to 0.63	0.15	6.6 to 7.8	Low.
(2/)----------	(2/)	(2/)	(2/)	(2/)	(2/)	(2/)	(2/).
(2/)----------	(2/)	(2/)	(2/)	(2/)	(2/)	(2/)	(2/).
A-2 or A-4------	85 to 95	80 to 90	25 to 50	2.00 to 6.30	0.13	6.1 to 6.5	Low.
A-2 or A-4------	85 to 95	80 to 90	25 to 50	2.00 to 6.30	0.10	6.1 to 6.5	Low.
A-2 or A-4------	85 to 90	75 to 85	25 to 50	0.63 to 2.00	0.10	6.1 to 6.5	Low.
A-4----------	85 to 90	80 to 90	50 to 65	0.63 to 2.00	0.18	5.1 to 5.5	Medium.
A-2----------	85 to 90	80 to 85	30 to 35	2.00 to 6.30	0.10	5.1 to 5.5	Low.
A-2 or A-4------	80 to 85	70 to 90	25 to 50	0.63 to 2.00	0.15	5.6 to 6.0	Low.
A-2 or A-4------	85 to 90	75 to 85	25 to 50	0.63 to 2.00	0.10	5.6 to 6.0	Low.
A-8----------	(2/)	(2/)	(2/)	(2/)	(2/)	(2/)	(2/).
(2/)----------	(2/)	(2/)	(2/)	(2/)	(2/)	(2/)	(2/).

TABLE 4.--ESTIMATED

Soil series and map symbols	Depth to water table	Depth from surface	Classification	
			USDA texture	Unified
	Ft.	In.		
Pomroy (PoA, PoB)	10+	0 to 8	Loamy fine sand	SP-SM
		8 to 34	Loamy sand	SP-SM
		34 to 48	Fine sandy loam	SM-SC
Ronneby (Ro)	2 to 4	0 to 16	Sandy loam	SM-SC
		16 to 48	Sandy loam	SM-SC
Salida complex (SaB, SaB2, SaC, SaC2, SaE)	10+	0 to 16	Loamy sand	SP-SM
		16 to 30	Coarse sand and gravel.	SP
		30 to 40	Gravel	GW
		40 to 54	Sand	SP
Wadena (WaA)	10+	0 to 9	Loam	SM or ML.
		9 to 24	Light clay loam	CL
		24 to 31	Sand and gravel	SP or GW.
		31 to 42	Gravel	GP
Zimmerman (ZmA, ZmA2, ZmB, ZmB2, ZmC, ZmC2, ZfE)	10+	0 to 3	Loamy fine sand	SP-SM
		3 to 64	Fine sand	SP-SM

1/ Approximately 10 percent of the soil material is more than 3 inches in diameter.

2/ Unclassified. Characteristics too variable to permit classification.

PROPERTIES--CONTINUED

Classification--continued	Percentage passing sieve--			Permeability	Available water capacity	Reaction	Shrink-swell potential
AASHO	No. 4 (4.7 mm.)	No. 10 (2.0 mm.)	No. 200 (0.074 mm.)				
				In./hr.	In./in. of soil	pH	
A-2	100	98 to 100	10 to 15	>6.30	0.07	5.1 to 5.5	Low.
A-2	100	98 to 100	10 to 15	>6.30	0.05	5.6 to 6.0	Low.
A-2 or A-4	85 to 90	75 to 85	25 to 50	0.20 to 0.63	0.15	5.6 to 6.0	Low.
A-2	85 to 90	80 to 85	30 to 35	0.63 to 2.00	0.13	5.6 to 6.0	Low.
A-2 or A-4	80 to 85	70 to 80	25 to 50	0.20 to 0.63	0.10	5.1 to 5.5	Low.
A-2	95 to 100	98 to 100	10 to 15	>6.30	0.07	5.6 to 6.0	Low.
A-1	50 to 80	30 to 50	2 to 5	>6.30	0.02	6.1 to 6.5	Low.
A-1	30 to 50	5 to 10	2 to 5	>6.30	0.02	7.4 to 7.8	Low.
A-2	80 to 90	75 to 90	2 to 5	>6.30	0.02	7.4 to 7.8	Low.
A-4	100	100	40 to 55	0.63 to 2.00	0.21	5.6 to 6.0	Low.
A-6	100	95 to 100	50 to 70	0.63 to 2.00	0.18	5.6 to 6.0	Medium.
A-1 or A-2	40 to 90	35 to 75	2 to 5	>6.30	0.02	5.6 to 6.0	Low.
A-1	40 to 50	35 to 45	2 to 5	>6.30	0.02	7.4 to 7.8	Low.
A-2	100	100	10 to 15	>6.30	0.05	5.1 to 5.5	Low.
A-2	100	100	5 to 12	>6.30	0.03	5.1 to 5.5	Low.

3/ Not determined.

TABLE 5.--ENGINEERING

Soil series and map symbols	Suitability as source of--			
	Topsoil	Sand	Gravel	Highway subgrade material
Adolph (Ap)----------	Surface layer good; subsoil poor.	Not suitable---------	Not suitable---	Not suitable for subbase: medium to low shear strength; poor compaction.
Alluvial land (Ad, Af)--	Surface layer good; subsoil fair.	Not suitable---------	Not suitable---	Not suitable---------
Beach sand (Ba)---------	Not suitable---------	Fair: mostly medium and coarse sand.	Not suitable---	Good for subbase-----
Becker (BeA, BeB)-------	Surface layer good; subsoil fair.	Not suitable---------	Not suitable---	Fair to depth of 3 to 4 feet; fair to good below 4 feet for subbase; high shear strength; moderately susceptible to frost action; good compaction.
Braham (BrA, BrB, BrB2, BrC, BrC2, BrD).	Poor: low water-holding capacity.	Suitable for subbase; not suitable for concrete; limited quality.	Not suitable---	Good at depth between 2 and 3 feet; fair to good below 3 feet; high shear strength; good compaction; susceptible to erosion. Substratum: fair to good compaction; moderately resistant to erosion.
Burkhardt (BuA, BuB, BuB2).	Surface layer fair; subsoil unsuitable.	Not suitable---------	Good: well-graded mixture of sand and gravel.	Surface soil suitable for base: compacts well. Subsoil excellent for subbase: resists erosion.

See footnote at end of page.

INTERPRETATIONS

Soil features affecting--				Degree of limitation for use as septic tank drainage field
Highway location	Agricultural drainage	Irrigation 1/	Waterways	
Very poor drainage; high susceptibility to frost action; cut banks highly erodible.	Moderately slow permeability.	Moderate water-holding capacity; infiltration rate 0.4 to 1 inch per hour.	Not needed--------	Severe: very poor drainage; high water table.
Frequent overflow-----	Moderate permeability; high water table; flooding.	Moderate water-holding capacity; infiltration rate 0.6 inch to 1.3 inches per hour.	Generally not needed, because of topographic position.	Severe: frequent overflow.
Water table affects subbase unless highway centerline is placed far enough away from beach.	Not needed; non-agricultural.	Not needed; non-agricultural.	Soil features unfavorable.	Severe: high water table.
Good drainage; moderate susceptibility to frost action; occasional high water table.	Not needed; good drainage.	Moderate water-holding capacity; infiltration rate 0.5 to 1 inch per hour.	Generally not needed, because of topographic position.	Slight: rapid percolation.
Good drainage; slight susceptibility to frost action.	Not needed; good or moderately good drainage.	Low to moderate water-holding capacity; infiltration rate 1 inch to 2 inches per hour.	Low water-holding capacity.	Moderate: moderate percolation.
Good drainage; slight susceptibility to frost action.	Not needed; excessive drainage.	Low water-holding capacity; shallow to gravel; infiltration rate 0.6 inch to 1.3 inches per hour; low fertility.	Shallow to gravel; difficult to establish vegetation if sand and gravel are exposed; low water-holding capacity; low fertility.	Slight: very rapid percolation; downslope seepage significant in places.

TABLE 5.--ENGINEERING

Soil series and map symbols	Suitability as source of--			
	Topsoil	Sand	Gravel	Highway subgrade material
Chetek (ChA, ChB, ChB2, ChC, ChC2, ChC3).	Surface layer fair; subsoil unsuitable.	Not suitable	Good to fair; well-graded to poorly graded mixture of sand and gravel.	Good for subbase: surface soil compacts for base; erodes easily on shoulders.
Dundas (Du)	Good	Not suitable	Not suitable	Poor to a depth of 3 feet; fair below 3 feet; subsoil compacts well for base and subbase; good surface drainage must be maintained.
Emmert: Gravelly loamy sands (EgC, EgE).	Not suitable	Not suitable	Good for road subbase and concrete.	Good for subbase. Variable in quality and in compaction characteristics for base.
Loamy sands (ElA, ElB, ElB2, ElC, ElC2, ElC3, EmD, EmD2, EmE, EmE2).	Not suitable	Not suitable	Good to fair: well-graded to poorly graded mixture of sand and gravel.	Good to fair for base: fair compaction; high shear strength.
Complex of Emmert and Hayden soils (ErB2, ErC2, ErD2, ErE2).	Poor	Not suitable	Poor	Good to fair for base: fair compaction; high shear strength.
Estherville (EsA, EsA2, EsB, EsB2, EsC, EsC2).	Surface layer fair; subsoil unsuitable.	Not suitable	Good: well-graded gravel; strata of medium to coarse sand in places.	Excellent for subbase: highly erodible on shoulders.

See footnote at end of table.

INTERPRETATIONS--CONTINUED

Soil features affecting--				Degree of limitation for use as septic tank drainage field
Highway location	Agricultural drainage	Irrigation 1/	Waterways	
Good drainage; coarse underlying material provides good subbase free of slippage and frost heaving.	Not needed; excessive drainage.	Low water-holding capacity; shallow to gravel; infiltration rate 0.6 inch to 1.3 inches per hour.	Shallow to gravel; low fertility; low water-holding capacity; difficult to establish vegetation if sand and gravel are exposed.	Slight: very rapid percolation; downslope seepage significant in places.
Perched water table at depth between 3 and 6 feet in spring; somewhat poor drainage; moderate susceptibility to frost action.	Moderately slow permeability.	High water-holding capacity; infiltration rate 0.5 to 1 inch per hour.	Wet in draws or at foot of slopes; difficult to tile; difficult to establish vegetation if wet.	Severe: high water table.
Good drainage in subbase; little or no frost action; cut banks vary in erodibility.	Not needed; excessive drainage.	Not needed; low agricultural value; very low water-holding capacity.	Very shallow to gravel; very low water-holding capacity; difficult to establish vegetation if gravel is exposed.	Slight: very rapid percolation. Severe on slopes of 18 percent because of downslope seepage.
Good drainage; coarse underlying material; cut banks resist erosion and are free of slippage and frost heaving.	Not needed; excessive drainage.	Very low water-holding capacity; shallow to gravel; infiltration rate 1 inch to 2 inches per hour; low fertility.	Shallow to gravel; low fertility; very low water-holding capacity; difficult to establish vegetation if sand and gravel are exposed.	Slight: very rapid percolation. Severe on slopes of 18 percent because of downslope seepage.
Good drainage; coarse underlying material; cut banks resist erosion and are free of slippage and frost heaving.	Not needed; good drainage.	Moderate to low water-holding capacity; infiltration rate 0.6 inch to 1.3 inches per hour.	Gravelly pockets; difficult to establish vegetation if gravel is exposed.	Moderate: moderate percolation. Severe on slopes of more than 18 percent.
Good drainage in subbase; very little frost heaving or instability; cut banks moderately erodible.	Not needed; somewhat excessive drainage.	Very low water-holding capacity; shallow to gravel; infiltration rate 0.6 inch to 1.3 inches per hour.	Shallow to gravel; low water-holding capacity; difficult to establish vegetation if sand and gravel are exposed.	Slight: very rapid percolation.

TABLE 5.--ENGINEERING

Soil series and map symbols	Suitability as source of--			
	Topsoil	Sand	Gravel	Highway subgrade material
Fairhaven (FaA, FaB)---	Good----------	Not suitable---------	Not suitable---	Not suitable: highly erodible; possibility of slippage; low shear strength; poor compaction.
Hayden (HaA, HaB, HaB2, HaC, HaC2, HaC3, HaD, HaD2, HaD3, HaE).	Good----------	Not suitable---------	Not suitable---	Good to fair: subsoil compacts well for base and subbase; good surface drainage must be maintained.
Hubbard: Loamy sands (HuA, HuA2, HuB, HuB2, HuB3, HuC, HuC2, HuC3, HuE, HuE2).	Not suitable---------	Good for road subbase: mostly medium sand; some interbedded strata of gravel.	Not suitable---	Good for subbase: high shear strength; fair to poor compaction.
Sandy loams (HyA, HyA2, HyB, HyB2, HyC2).	Surface layer fair; subsoil unsuitable.	Good for road subbase: mostly medium sand; some interbedded strata of gravel.	Not suitable---	Good for subbase: medium shear strength; good compaction.
Isanti (Is)----------	Poor----------	Fair for road subbase: mostly medium and fine sand.	Not suitable---	Fair for subbase and base: fair compaction; medium shear strength.
Lino (LnA, LnA2, LnB, LsA).	Poor----------	Good for road subbase: mostly medium and fine sand.	Not suitable---	Good for subbase and base: medium shear strength; shoulders erodible; fair to poor compaction.
Loamy wet land (Lw)----	Fair: cloddy or lumpy in places.	Not suitable---------	Not suitable---	Not suitable: too variable.

See footnote at end of table.

INTERPRETATIONS--CONTINUED

Soil features affecting--				Degree of limitation for use as septic tank drainage field
Highway location	Agricultural drainage	Irrigation 1/	Waterways	
Possibility of slippage or slumping; susceptibility to frost heaving.	Not needed; good drainage.	Moderate water-holding capacity; infiltration rate 0.5 to 1 inch per hour.	Soil highly erodible.	Slight: rapid percolation.
Good stability as subbase where surface drainage is adequate; some susceptibility to frost action; cut banks erodible.	Not needed; good drainage.	High water-holding capacity; infiltration rate 0.5 inch to 1.3 inches per hour.	Soil highly erodible.	Moderate: moderate percolation. Severe on slopes of more than 18 percent.
Excellent stability as subbase; no drainage problem; slight susceptibility to frost action; cuts and banks highly erodible.	Not needed; excessive drainage.	Very low water-holding capacity; infiltration rate of 1 inch to 2 inches per hour; low agricultural value.	Very low water-holding capacity; soil highly erodible.	Slight: rapid percolation. Severe on slopes of more than 18 percent.
Good drainage; little danger of frost action; cut banks highly erodible.	Not needed; excessive drainage.	Low water-holding capacity; infiltration rate 0.6 inch to 1.3 inches per hour.	Low water-holding capacity; highly erodible.	Slight: rapid percolation.
Poor drainage; roadbed needs good internal drainage and surface drainage; drainage lessens danger of frost action; cut banks erodible.	Rapid permeability---	Very low or low water-holding capacity; infiltration rate 1 inch to 2 inches per hour.	Not needed in depressions.	Severe: high water table.
Poor drainage; roadbed needs good internal drainage and surface drainage; drainage lessens danger of frost action.	Rapid permeability---	Very low water-holding capacity; infiltration rate 1 inch to 2 inches per hour.	Low water-holding capacity.	Severe: high water table.
Poor drainage; tile or deep drainage ditches needed.	Moderately slow to rapid permeability.	Not needed----------	Not needed in depressions.	Severe: high water table.

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TABLE 5.--ENGINEERING

Soil series and map symbols	Suitability as source of--			
	Topsoil	Sand	Gravel	Highway subgrade material
Milaca (MfA, MfB, MfB2, MfC2, MfD, MfE).	Surface layer good; subsoil poor.	Not suitable---------	Not suitable---	Subsoil good for subbase in well-drained locations; medium shear strength; fair compaction.
Mora (MoA, MoB)-------	Surface layer good; subsoil poor.	Not suitable---------	Not suitable---	Subsoil good for base: good compaction; medium shear strength.
Peat and muck (Pa, Pc, Pd).	Poor-----------------	Not suitable---------	Not suitable---	Not suitable: all peat and muck must be removed from construction zone.
Peat-Lino (Pn)--------	Not suitable---------	Fair to poor---------	Not suitable---	Not suitable: variable.
Pomroy (PoA, PoB)-----	Poor: low water-holding capacity.	Suitable for road subbase. Not suitable for concrete: limited quantity.	Not suitable---	Good: high shear strength; fair to good compaction; moderately erodible.
Ronneby (Ro)----------	Surface layer good; subsoil poor.	Not suitable---------	Not suitable---	Good: high shear strength; fair compaction; moderately erodible.
Salida (SaB, SaB2, SaC, SaC2, SaE).	Not suitable---------	Not suitable---------	Good: well-graded gravel; strata of medium and coarse sand in places.	Subsoil excellent for subbase. Surface soil moderately compactible; high shear strength.

See footnote at end of table.

INTERPRETATIONS--CONTINUED

Soil features affecting--				Degree of limitation for use as septic tank drainage field
Highway location	Agricultural drainage	Irrigation 1/	Waterways	
Moderate susceptibility to frost action if surface drainage is provided; cut banks moderately erodible.	Not needed; good drainage.	Moderate water-holding capacity; infiltration rate 0.6 inch to 1.3 inches per hour.	Soil moderately erodible; rockiness interferes with construction.	Severe: moderately slow percolation; fragipan; seepage likely on steep slopes.
External and internal drainage needed to stabilize roadbed; drainage lessens danger of frost action.	Not needed; good drainage.	Moderate water-holding capacity; infiltration rate 0.4 to 1 inch per hour.	Soil moderately erodible; rockiness interferes with construction.	Severe: moderately slow percolation; fragipan.
Features unfavorable; all peat and muck must be removed from construction zone.	Moderate permeability; high water table; side slopes need to be stabilized.	Very high water-holding capacity; infiltration rate 1 inch to 2 inches per hour.	Not needed; level-	Severe: high water table.
Features unfavorable and variable.	Rapid permeability; high water table.	Low or very low water-holding capacity; infiltration rate 1 inch to 2 inches per hour.	Not needed; depressional areas.	Severe: high water table.
Good drainage; slight susceptibility to frost action.	Not needed; good or moderately good drainage.	Low or moderate water-holding capacity; infiltration rate 1 inch to 2 inches per hour.	Low water-holding capacity.	Severe: moderately slow percolation; fragipan.
Perched water table at a depth between 2 and 4 feet in spring; somewhat poor drainage; moderate susceptibility to frost action.	Moderately slow permeability; fragipan.	Moderate water-holding capacity; infiltration rate 0.4 to 1 inch per hour.	Rocks throughout profile; soil moderately erodible.	Severe: moderately slow percolation; high water table; fragipan.
Good drainage; slight susceptibility to frost action; cut banks in subsoil moderately erodible.	Not needed; excessive drainage.	Very low water-holding capacity; infiltration rate 1 inch to 2 inches per hour.	Shallow to gravel; very low water-holding capacity; difficult to establish vegetation.	Slight: very rapid percolation. Severe on slopes of more than 18 percent.

TABLE 5.--ENGINEERING

Soil series and map symbols	Suitability as source of--			
	Topsoil	Sand	Gravel	Highway subgrade material
Wadena (WaA)----------	Surface layer good; subsoil unsuitable.	Not suitable----------	Good: well-graded gravel; strata of medium and coarse sand in places.	Subsoil excellent for subbase. Surface soil compacts well; medium shear strength; shoulders erodible.
Zimmerman (ZmA, ZmA2, ZmB, ZmB2, ZmC, ZmC2, ZfE).	Not suitable---------	Good for subbase: mostly fine and medium sand.	Not suitable---	Good for subbase and base fill: high shear strength; poor compaction; shoulders highly erodible.

1/ Rate of water intake depends on whether soil is covered with vegetation or is bare.

Factors of Soil Formation

The characteristics of the soil at any given point are determined by (1) the physical and mineralogical composition of the parent material; (2) the climate under which the soil material has accumulated and existed since accumulation; (3) the living organisms on and in the soil, mainly vegetation; (4) the relief, or lay of the land; and (5) the length of time the forces of soil development have acted on the soil material. The relative effect of each of these factors is reflected in the soil profile.

During the transformation of the parent material into soil, minerals weather and organic matter accumulates. Material in suspension or in solution moves downward through the soil, and new chemical compounds and new minerals form.

In Sherburne County, differences in parent material and vegetation account for most of the differences among the soils. Climate and relief are fairly uniform throughout the county, and all of the soils have been developing for about the same length of time.

The five factors of soil formation are interdependent, each modifying the effects of the others. These factors as they occur in Sherburne County are described in the pages that follow.

Parent material [3]

Deposits of glacial till, outwash sand and gravel, and ancient coarse alluvium along the Mississippi River are the most extensive sources of parent material in Sherburne County. All of this material was deposited during the Wisconsin stage (the last major glacial stage) of the Pleistocene epoch. Less extensive sources are recent alluvium and organic material.

[3] JOHN E. STONE, geologist, Minnesota Geological Survey, helped prepare this section.

Two kinds of glacial drift of slightly different age and markedly different composition have been deposited in the county. The older drift was deposited by ice of the Superior lobe, which flowed into the area from the north. The till in this drift is reddish brown in color, generally coarse textured, and noncalcareous. It is commonly referred to as "red till." Pebbles of basalt, gabbro, felsite, and red sandstone are common. The Superior lobe retreated from the area about 13,500 years ago. The Milaca, Mora, and Ronneby soils, which are near Santiago, developed from till deposited by the Superior lobe (see fig. 4, p. 5).

Later, the Grantsburg sublobe, a protrusion of the Des Moines lobe, advanced into the area. This ice flowed generally northward, almost to the northern border of Sherburne County, and brought a light olive-brown, medium-textured, calcareous drift that contained pebbles of limestone and shale. The till deposited by the Des Moines lobe is commonly referred to as "gray till" or "buff till." In some places the Grantsburg sublobe picked up deposits previously laid down by the Superior lobe; consequently, complex mixtures of reddish-brown and light olive-brown drift were deposited in some areas. Such mixtures are visible on the islands of till that project through the sand plain north of Becker and northeast of Elk River. A thin smear of sand generally mantles the surface on the lower slopes of these till islands. The Hayden, the Braham, and some of the Emmert soils (see fig. 5, p. 6) developed from till deposited by the Grantsburg sublobe.

During the retreat of the Grantsburg sublobe, about 12,500 years ago, the ice stagnated in the northern and and eastern parts of the county. Melt water left intermixed outwash gravel and sand from both the Grantsburg and Superior lobes in a large crevase in the ice along the eastern edge of the county. When the ice melted, this outwash deposit remained and rose above the surround-

INTERPRETATIONS--CONTINUED

Soil features affecting--				Degree of limitation for use as septic tank drainage field
Highway location	Agricultural drainage	Irrigation 1/	Waterways	
Good drainage; moderate susceptibility to frost action.	Not needed; excessive drainage.	Moderate water-holding capacity; infiltration rate 0.45 to 1 inch per hour.	Soil moderately erodible.	Slight: very rapid percolation.
Good drainage; slight susceptibility to frost action; cut banks highly erodible.	Not needed; excessive drainage.	Very low water-holding capacity; infiltration rate of 1 inch to 2 inches per hour.	Very low water-holding capacity; soil highly erodible.	Slight: rapid percolation. Severe on slopes of more than 18 percent.

ing countryside. The Burkhardt, Chetek, and Emmert soils (see fig. 6, p. 7) developed in this gravelly and sandy material.

Still later, the ice became stabilized along the northeastern edge of the Mississippi Valley, and melt water produced an outwash apron sloping toward the northeast. The material deposited by the melt water consisted of well-stratified fine sand, part of which had not been deeply reworked by wind. The Zimmerman, Lino, and Isanti soils developed in these fine sands (see fig. 3, p. 4).

Finally, the Grantsburg sublobe retreated westward, uncovering the Mississippi Valley. Melt water from the wasting Des Moines lobe filled the valley in Sherburne County with coarse alluvium. This alluvium underlies two broad terraces that are parallel to the Mississippi River. The sand is coarse textured in areas near the river and becomes increasingly finer textured with increasing distance from the river. It is poorly stratified and generally is deeply leached. In places it is underlain by strata of calcareous gravel. The soils of this area are the Hubbard, Esterville, and Salida soils (see fig. 2, p. 3).

As the glacier retreated from the area, large blocks of ice were left in the till and outwash. The melting of these blocks produced depressions in nearly all of the glacial deposits. Many of these depressions are now lakes or swamps. Organic soils developed in shallow depressions where water stood for part of the year, and along drainageways that were frequently flooded. The organic material is 12 to more than 42 inches thick. In some areas large sand dunes developed on the deposits of fine sand, probably soon after the ice melted and before vegetation became well established.

Recent alluvium, the texture of which ranges from loam to sand, has been deposited on the flood plains of the major streams in the county.

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Climate

The climate, a continental type, is essentially uniform throughout the county. The temperature varies widely from summer to winter. Generally, the soils are frozen 4 or 5 months each year.

Vegetation

Soils of the same age that have similar relief, drainage, and parent material have a thicker, darker colored surface layer if the native vegetation has been grass than if it has been forest. The largest area of grass in Sherburne County is the outwash plain along the Mississippi River, but even here, oaks have invaded to some extent (fig. 16). The Hubbard, Estherville, and Wadena soils developed in this area.

Figure 16.—**Scattered bur oak on Hubbard loamy sand, in the transition zone between the open prairie and the forest.**

In forested areas not only is the surface layer lighter colored than in grassy areas, but the downward movement of clay and plant nutrients is more rapid and the subsoil is less permeable. The principal trees on the sand plain are bur oak and northern pin oak. Mixed hardwoods grow on the areas of glacial till (fig. 17). The Hayden, Milaca, Chetek, Mora, and Zimmerman soils developed under forest.

Figure 17.—**Bur oak and northern pin oak on Zimmerman loamy fine sand.**

Relief

Soil develops most rapidly on well-drained gentle slopes. Soil development is very slow on steep slopes where runoff is rapid, infiltration is slow, and geologic erosion removes the surface soil about as fast as it forms. Little or no development takes place in depressions or level areas where there is a permanent high water table, except in a warm climate. A soil that develops where relief and drainage favor the growth of prairie grasses tends to have a thicker surface layer and is likely to contain more organic matter than a soil that develops under trees.

Differences in topography also influence the development of different soils that formed in the same kind of parent material. For example, the Milaca, Mora, Ronneby, and Adolph soils all formed in noncalcareous, red glacial till. The Milaca are well-drained soils that developed mainly on gentle to moderately steep slopes where runoff was good but not rapid enough to cause excessive erosion. The Mora are moderately well drained soils that developed in nearly level and gently sloping areas where runoff was a little slower and more of the rainfall percolated into the soil. The Ronneby are somewhat poorly drained soils that developed in nearly level and level areas at the base of long slopes, where runoff was slow. The Adolph are poorly drained soils that developed in level areas where runoff was very slow. These soils are saturated much of the time. They have a high water table and poor internal drainage.

Time

The length of time the parent material has been in place and exposed to the active forces of climate and vegetation is an important factor in soil formation, but the age of a soil refers to the degree of profile development and is influenced by other factors as well as by time. A mature soil is one that has well-defined horizons. An immature soil is one that shows little or no horizonation. Because of differences in parent material, climate, relief, and vegetation, soils that have been developing for about the same length of time have not necessarily reached the same degree of profile development. If the parent material weathers slowly, profile development is slow. If the slope is steep, soil is removed almost as soon as it forms and, consequently, no well-defined horizons develop. On flood plains, the frequent deposition of fresh alluvium delays the development of a distinct profile.

Classification of the Soils

Two systems of classifying soils are now in general use in the United States. One of these is the 1938 system (*4*), with later revisions. The other, the current system [4], has been used by the Cooperative Soil Survey since 1965. Both are used in this publication.

The current system has six categories. Beginning with the most inclusive, these categories are the order, the suborder, the great group, the subgroup, the family, and the series. In this system the criteria for classification are the observable or measurable properties. The properties are so chosen that soils of similar mode of origin are grouped together. Placement of some soil series in the current system of classification, particularly in families, may change as more precise information becomes available. Readers interested in the development of this system should search the latest available literature (*8*).

The 1938 system, with later revisions, also has six categories, the most inclusive of which is the order. The next two categories, the suborder and the family, have never been fully developed and consequently have been little used. Attention has been centered largely on the great soil group, the soil series, and the soil type.

Table 6 shows the classification of each soil series of Sherburne County by family, subgroup, and order of the current classification system, and according to the great soil group of the 1938 system.

New soil series must be established and concepts of some established series, especially older ones that have been used little in recent years, must be revised in the course of the soil survey program across the country. A proposed new series has tentative status until review of the series concept at State, regional, and national levels of responsibility for soil classification result in a judgment that the new series should be established. All of the soil series described in this publication except the Mora series were established before this survey was made. The Mora series had tentative status when the survey manuscript was sent to the printer.

[4] UNITED STATES DEPARTMENT OF AGRICULTURE. SOIL CLASSIFICATION, A COMPREHENSIVE SYSTEM, 7TH APPROXIMATION. 1960. 265 pp., illus. [Supplement issued in March 1967]

TABLE 6.--SOIL SERIES CLASSIFIED ACCORDING TO THE CURRENT SYSTEM OF CLASSIFICATION AND THE 1938 SYSTEM, WITH ITS LATER REVISIONS

Series	Current classification			1938 classification
	Family	Subgroup	Order	Great soil group
Adolph	Fine loamy, mixed, mesic	Aqueptic Haplaquolls	Mollisols	Humic Gley soils.
Becker	Fine loamy, mixed, mesic	Cumulic Hapludolls	Mollisols	Alluvial soils.
Braham	Sandy over fine loamy, mixed, mesic.	Arenic Eutrochrepts	Inceptisols	Regosols intergrading toward Gray-Brown Podzolic soils.
Burkhardt	Coarse loamy over sandy skeletal, mixed, frigid.	Typic Hapludolls	Mollisols	Brunizems.
Chetek	Coarse loamy over sandy skeletal, mixed, frigid.	Typic Normudalfs	Alfisols	Gray-Brown Podzolic soils.
Dundas	Fine, montmorillonitic, mesic.	Mollic Albaqualfs	Alfisols	Planosols intergrading toward Gray-Brown Podzolic soils.
Emmert	Fragmental, siliceous, nonacid, frigid.	Typic Udipsamments	Entisols	Regosols.
Estherville	Coarse loamy over sandy skeletal, mixed, mesic.	Typic Hapludolls	Mollisols	Brunizems.
Fairhaven	Fine loamy over sandy skeletal, mixed, mesic.	Typic Hapludolls	Mollisols	Brunizems.
Hayden	Fine loamy, mixed, mesic	Typic Normudalfs	Alfisols	Gray-Brown Podzolic soils.
Hubbard	Sandy, siliceous, nonacid, frigid.	Entic Haploborolls	Mollisols	Brunizems.
Isanti	Sandy, siliceous, nonacid, frigid.	Psammentic Haplaquolls	Mollisols	Humic Gley soils.
Lino	Sandy, siliceous, nonacid, frigid.	Aquic Udipsamments	Entisols	Low-Humic Gley soils.
Milaca	Fine loamy, mixed, frigid	Typic Fragiudalfs	Alfisols	Gray-Brown Podzolic soils.
Mora	Fine loamy, mixed, frigid	Typic Fragiudalfs	Alfisols	Gray-Brown Podzolic soils.
Pomroy	Sandy, siliceous, nonacid, frigid.	Typic Udipsamments	Entisols	Regosols.
Ronneby	Fine loamy, mixed, frigid	Aquic Fragiudalfs	Alfisols	Low-Humic Gley soils.
Salida	Sandy skeletal, mixed, mesic.	Entic Hapludolls	Mollisols	Regosols intergrading to Brunizems.
Wadena	Fine loamy over sandy skeletal, mixed, mesic.	Typic Hapludolls	Mollisols	Brunizems.
Zimmerman	Sandy, siliceous, nonacid, frigid.	Alfic Udipsamments	Entisols	Regosols.

Descriptions of Soil Profiles

In the following pages are descriptions of typical soil profiles for all series in the county. All color notations in these descriptions are for moist soil.

Adolph Series

The Adolph series consists of poorly drained, level or slightly depressional soils within ground moraines. These soils developed under deciduous trees and swamp grasses in noncalcareous, red glacial till. The till is moderately coarse textured and contains many rocks and cobblestones. The largest acreage of these soils is in the northern part of the county, mainly in Santiago and Blue Hill Townships.

The Adolph soils in Sherburne County differ somewhat from the Adolph soils of the central concept, which develop in silty material over red till and are gleyed to a greater depth.

Adolph soils are members of the catena that includes the well drained Milaca soils, the moderately well drained Mora soils, and the somewhat poorly drained Ronneby soils. They are wetter than Ronneby soils, have a thicker, darker colored A horizon, and occupy a lower topographic position. They occupy higher positions than the very poorly drained Loamy wet land, with which they are associated in places, and are ponded for shorter periods.

Profile of Adolph loam in a meadow south of the east-west road, in the NE¼SE¼ sec. 5, T. 35 N., R. 27 W.

Ap—0 to 12 inches, black (10YR 2/1) loam; few, fine, faint, very dark brown (10YR 2/2) and dark-brown (7.5YR 3/2) mottles; moderate to weak, coarse, angular blocky structure; friable when moist; neutral; gradual, wavy boundary.

A3g—12 to 19 inches, very dark brown (10YR 2/2) and very dark gray (10YR 3/1) loam; many, medium, faint, dark-brown (7.5YR 3/2), dark grayish-brown (10YR 4/2), and grayish-brown (10YR 5/2) mottles; weak, thin, platy structure; friable when moist; slightly acid; clear, wavy boundary.

B2—19 to 40 inches, dark-brown (7.5YR 4/4) heavy sandy loam; many, medium, faint, brown (7.5YR 5/4 and 5/2) and reddish-gray (5YR 5/2) mottles; moderate, very thin and thin, platy structure; friable when moist; neutral; gradual, wavy boundary.

C—40 to 48 inches, reddish-brown (5YR 4/3) heavy sandy loam; many, medium, faint, reddish-brown (5YR 5/3) and reddish-gray (5YR 5/2) mottles; moderate, medium, angular blocky structure breaking to massive; slightly sticky and slightly plastic when wet; neutral.

In places the texture of the surface layer is very fine sandy loam. The thickness of the A horizon ranges from 8 to 19 inches. The texture of the underlying material ranges from heavy sandy loam to light sandy loam. The degree of stoniness varies considerably. Sandy pockets are common in the substratum. The substratum is generally acid, but in spots it is neutral or even calcareous.

Becker Series

The Becker series consists of nearly level or undulating, moderately well drained or well drained soils that are underlain by sand at a depth of 24 to 42 inches. These soils developed under prairie grass in alluvial deposits of medium-textured material. They occur on high terraces along the Mississippi River.

Becker soils differ from Wadena soils in lacking a B horizon. They are closely associated with Alluvial land, frequently flooded, which is on the Mississippi River bottoms. They are more uniform in texture than Alluvial land and, because they occupy a higher topographic position, are not subject to flooding.

Profile of Becker very fine sandy loam in a cultivated field in the SW¼NW¼ sec. 23, T. 34 N., R. 30 W.

Ap—0 to 6 inches, black (10YR 2/1) very fine sandy loam; moderate, medium and coarse, granular structure; very friable when moist; neutral; clear, wavy boundary.

A12—6 to 26 inches, black (10YR 2/1) very fine sandy loam grading to very dark gray (10YR 3/1) in lower part of horizon; weak, coarse, angular blocky structure; friable when moist; neutral; clear, wavy boundary.

C1—26 to 34 inches, very dark grayish-brown (10YR 3/2) very fine sandy loam grading downward to loamy very fine sand; weak, medium to coarse, angular blocky structure; very friable when moist; neutral; gradual, wavy boundary.

C2—34 to 48 inches, brown (10YR 4/3) loamy very fine sand; structureless; very friable when moist; neutral.

The texture of the A1 horizon ranges from very fine sandy loam to loam. In places the underlying material is sandy gravel. In some areas the surface is corrugated. In these areas the swales generally have deeper, medium-textured deposits than the crests. Sandy spots occur in places.

Braham Series

The Braham series consists of nearly level to steep, well drained or moderately well drained soils. These soils are underlain by gray glacial till or medium-textured lacustrine material at a depth of 24 to 42 inches. They developed under forest vegetation in windblown or water-laid deposits of sand. They occur on the edges of the islands of glacial till that project through the sand plain north of Becker and Elk River and near Santiago.

Braham soils are associated with Hayden and Zimmerman soils and ordinarily occur as a transition zone between these two soils. They differ from Hayden soils in having loamy fine sand instead of fine sandy loam in the upper part of the solum, and silt loam and silty clay loam instead of loam to clay loam in the lower part. They differ from Zimmerman soils in being underlain by medium-textured material. They differ from Pomroy soils in having brown to grayish-brown, moderately fine textured and medium-textured material instead of reddish-brown and brown, moderately coarse textured glacial till in the lower part of the solum. Braham soils are members of the catena that includes the somewhat poorly drained Lino soils, from which they differ in topographic position and in the degree of wetness and the degree and intensity of mottling in the solum. Braham soils are not mottled above a depth of 24 inches.

Profile of Braham loamy fine sand 50 feet in a cultivated field in the SE¼NE¼SE¼ sec. 9, T. 35 N., R. 28 W.

Ap—0 to 8 inches, very dark brown (10YR 2/2) loamy fine sand; single grain; loose both when dry and when moist; strongly acid; abrupt, smooth boundary.

A3—8 to 29 inches, dark grayish-brown (10YR 4/2) fine sand; single grain; loose both when dry and when moist; medium acid; abrupt, smooth boundary.

IIB21—29 to 36 inches, brown (10YR 5/3) silty clay loam; many, fine, faint, brown (10YR 4/3) and yellowish-brown (10YR 5/4) mottles; strong, very fine and fine, angular blocky structure; very firm when moist, sticky and very plastic when wet; slightly acid; clear, wavy boundary.

IIB22—36 to 40 inches, light brownish-gray (10YR 6/2) silty clay loam; many, fine, distinct, strong-brown (7.5YR 5/6) and yellowish-brown (10YR 5/6) mottles; strong, very fine, angular blocky structure; firm when moist, sticky and very plastic when wet; slightly acid; clear, wavy boundary.

IIB3—40 to 44 inches, grayish-brown (10YR 5/2) silty clay loam; many, fine, faint, yellowish-brown (10YR 5/4 and 5/6) and dark yellowish-brown (10YR 4/4) mottles; strong, very fine, angular blocky structure; very firm when moist, sticky and very plastic when wet; slightly acid; clear, wavy boundary.

IIC1—44 to 54 inches, brown (10YR 4/3) silt loam; massive; friable when moist, slightly sticky and slightly plastic when wet; slightly acid.

The texture of the uppermost 12 inches of the A horizon ranges from loamy fine sand to light fine sandy loam. The color of the Ap horizon ranges from very dark brown (10YR 2/2) to very dark grayish brown (10YR 3/2). Mottles are lacking on the well-drained steeper slopes, but there are faint or distinct mottles in the lower part of the profile in some nearly level areas. In many places the IIC1 horizon is clay loam instead of silt loam.

The thickness of the sandy A horizons is normally between 24 and 42 inches. In areas where Hayden and Braham soils are adjacent, the soils that have a sandy A horizon more than 18 inches thick are classified as Braham soils, and those that have an A horizon less than 18 inches thick are classified as Hayden soils. In spots the medium-textured IIB or IIC horizon is a band 12 to 18 inches thick underlain by sand.

Burkhardt Series

The Burkhardt series consists of nearly level or undulating, somewhat excessively drained soils that are underlain by noncalcareous gravel at a depth of 18 to 24 inches. These soils developed in noncalcareous, gravelly glacial outwash, predominantly under native grass. Some areas occur in the rough, morainic hills in the eastern part of the county in Elk River and Livonia Townships, and others occur in the northwestern part of the county in Haven and Palmer Townships.

Burkhardt soils are associated with Chetek soils and are similar to Estherville soils. They have a thicker, darker colored surface layer than Chetek soils. As compared with Estherville soils, they are underlain by noncalcareous gravel instead of calcareous sand and gravel.

Profile of Burkhardt sandy loam in a virgin site in the NE¼NW¼NE¼ sec. 34, T. 34 N., R. 26 W.

O2—½ inch to 0, grass roots and organic matter.
A1—0 to 6 inches, black (10YR 2/1) sandy loam; weak, very fine, crumb structure; very friable when moist; strongly acid; gradual, irregular boundary.
AB—6 to 13 inches, very dark brown (10YR 2/2) sandy loam with inclusions of very dark grayish brown (10YR 3/2); weak, fine, angular blocky structure; very friable when moist; strongly acid; clear, wavy boundary.
B2—13 to 22 inches, dark-brown (7.5YR 3/2) sandy loam; weak, fine, angular blocky structure; very friable when moist; strongly acid; clear, wavy boundary.
IIC1—22 to 28 inches, dark-brown, (10YR 3/3) loamy sand; many cobblestones; single grain; very friable when moist; medium acid; clear, wavy boundary.
IIC2—28 to 36 inches, dark-brown to brown (7.5YR 4/3) coarse gravel; single grain; loose both when dry and when moist; medium acid.

The color of the surface layer ranges from black to very dark gray, and the texture from sandy loam to loam. Where the texture is loam, the surface layer is generally less than 15 inches thick. In places pebbles and cobblestones occur in the surface layer and subsoil. There may be an accumulation of clay in the IIC1 horizon, just above the gravel. In spots the gravel in the substratum is calcareous at a depth of 6 feet or more.

Chetek Series

The Chetek series consists of nearly level to rolling, somewhat excessively drained soils that are underlain by noncalcareous outwash sand and gravel at a depth of 18 to 24 inches. These soils developed under forest vegetation. They occur in the morainic area in the eastern part of the county in Elk River and Livonia Townships.

Chetek soils are associated with Burkhardt and Emmert soils. They have a lighter colored surface layer than Burkhardt soils. They are deeper over gravel than Emmert soils and have a solum of sandy loam instead of loamy sand.

Profile of Chetek sandy loam in a virgin site in the SE¼SE¼ sec. 27, T. 34 N., R. 26 W.

O1—1 inch to 0, grass roots and leaves.
A1—0 to 1 inch, black (10YR 2/1) to very dark brown (10YR 2/2) sandy loam; moderate, fine, granular structure; very friable when moist; medium acid; smooth, abrupt boundary.
A2—1 to 17 inches, brown (7.5YR 4/2) sandy loam; massive, breaking to weak, fine, crumb structure; very friable when moist; medium acid; gradual, wavy boundary.
B1—17 to 20 inches, reddish-brown (5YR 4/3) sandy loam; weak, fine and medium, angular blocky structure; firm when moist; strongly acid; clear, wavy boundary.
B2—20 to 23 inches, dark reddish-brown (5YR 3/4) fine sandy loam; weak, medium, angular blocky structure; firm when moist, sticky and plastic when wet; strongly acid; clear, wavy boundary.
IIC1—23 to 42 inches, brown (7.5YR 4/4) sand and coarse sand; single grain; loose both when dry and when moist; medium acid; gradual, wavy boundary.
IIC2—42 to 48 inches, brown (7.5YR 4/4) gravel; single grain; loose both when dry and when moist; medium acid.

In many places the color of the B horizon is brown (7.5YR 4/4) instead of reddish brown and dark reddish brown.

Dundas Series

The Dundas series consists of nearly level or undulating, somewhat poorly drained soils. These soils developed under hardwoods and grass in gray, calcareous glacial till. They occur north of Becker and Elk River, and also on the till islands that project through the sand plain in the northwestern part of the county.

Dundas soils are associated with the well-drained Hayden soils. They are wetter than Hayden soils and have mottles throughout the profile.

Profile of Dundas loam in a cultivated field in the SW¼SW¼SE¼ sec. 29, T. 34 N., R. 26 W.

Ap—0 to 7 inches, very dark gray (10YR 3/1) to very dark brown (10YR 2/2) loam; weak, coarse, subangular blocky structure; friable when moist; slightly acid; smooth, abrupt boundary.
A2—7 to 11 inches, dark-gray (10YR 4/1) fine sandy loam; common, fine, faint, dark-brown (10YR 4/3), dark yellowish-brown (10YR 4/4), and brown (10YR 5/3) mottles; weak, medium, subangular blocky structure breaking to moderate, medium, platy; friable when moist; slightly acid; clear, wavy boundary.
B1—11 to 19 inches, unevenly mottled, grayish-brown (10YR 5/2), dark grayish-brown (10YR 4/2), and dark-brown (10YR 4/3) heavy loam; moderate, coarse, subangular blocky structure breaking to moderate, medium and fine, subangular blocky; slightly sticky and plastic when wet; slightly acid; clear, wavy boundary.
B21—19 to 23 inches, dark grayish-brown (10YR 4/2) clay loam; many, fine, faint, dark-brown (10YR 4/3) to dark yellowish-brown (10YR 4/4) mottles; moderate, medium, angular blocky structure; sticky and very plastic when wet; very dark brown (10YR 2/2) clay coatings along root channels and on 10 percent of ped faces; slightly acid; clear, wavy boundary.
B22—23 to 32 inches, dark grayish-brown (10YR 4/2) clay loam; many, fine, faint mottles of dark brown (10YR 4/3) and dark yellowish brown (10YR 4/4); strong, fine and medium, angular blocky structure; sticky and very plastic when wet; very dark brown (10YR 2/2) organic staining in root channels and on 30 percent of ped faces; slightly acid; clear, wavy boundary.
C1—32 to 42 inches, olive-gray (5Y 5/2) loam to clay loam; many, fine, distinct, light olive-brown (2.5Y 5/4–5/6) mottles; massive, breaking to weak, very fine, angular blocky structure; sticky and plastic when wet; strong effervescence with dilute acid; white lime nodules and threads.

The surface layer is grayish brown (10YR 5/2) when dry. Its texture ranges from silt loam to fine sandy loam.

Emmert Series

The Emmert series consists of undulating to very steep, excessively drained soils that are underlain by stony and gravelly material at a depth of 6 to 18 inches. These soils developed under forest vegetation in stony and gravelly, noncalcareous, red glacial till. They occur in the morainic area in the eastern part of the county, chiefly in Elk River and Livonia Townships.

Emmert soils are associated with the somewhat excessively drained Chetek soils and to a minor extent with Milaca and Hayden soils. They have a thinner and coarser textured solum than Chetek soils, have weaker horizonation, and are shallower over gravel or gravelly sand.

Profile of Emmert gravelly loamy sand in a virgin site in the SE¼SW¼SE¼ sec. 26, T. 34 N., R. 26 W.

O2—½ inch to 0, grass roots and organic matter.
A1—0 to 2 inches, black (10YR 2/1) gravelly loamy sand; strong, fine, granular structure; very friable when moist; strongly acid; abrupt, smooth boundary.
A3—2 to 6 inches, very dark grayish-brown (10YR 3/2) gravelly loamy sand and cobblestones; single grain; very friable when moist; strongly acid; clear, wavy boundary.
IIC1—6 to 48 inches, brown to dark-brown (7.5YR 4/3) coarse gravel; single grain; loose when dry and moist; strongly acid.

On steep slopes the surface layer consists of gravelly loamy sand mixed with cobblestones. On the lesser slopes the texture grades to loamy sand, and in spots it is light sandy loam. The substratum is either gravel or gravelly sand. The depth to gravel decreases as the slope becomes steeper. On steep slopes it is generally less than 6 inches. The gravel is generally acid, but in spots it is calcareous at a depth of 6 feet or more. There are some pockets where the gravel is mixed with small amounts of red till.

Estherville Series

The Estherville series consists of nearly level to sloping, somewhat excessively drained sandy loams that are underlain by sand or gravel at a depth of 12 to 24 inches. These soils developed under prairie grass in calcareous, gravelly and sandy outwash. They occur on the outwash plain in the southern and western parts of the county, mainly in the townships adjacent to the Mississippi River.

Estherville soils are closely associated with Hubbard, Wadena, and Salida soils. As compared with Hubbard soils, they overlie calcareous gravel instead of deeply leached sand. They have a coarser textured solum than Wadena soils. Their A and B horizons are sandy loam; those of the Salida soils are loamy sand.

Profile of Estherville sandy loam in a cultivated field in the SE¼SE¼NE¼ sec. 33, T. 35 N., R. 30 W.

Ap—0 to 8 inches, black (10YR 2/1) sandy loam; very weak, fine, granular structure; friable when moist; medium acid; gradual, wavy boundary.
A12—8 to 12 inches, very dark brown (10YR 2/2) sandy loam; very weak, fine, subangular blocky structure; friable when moist; medium acid; gradual, wavy boundary.
B2—12 to 20 inches, brown to dark-brown (10YR 4/3) light sandy loam; very weak, fine, subangular blocky structure; very friable when moist; medium acid; gradual, wavy boundary.
B3—20 to 22 inches, dark-brown (10YR 4/3) gravelly sandy loam; single grain; loose when dry or moist; medium acid; clear, wavy boundary.
IIC1—22 to 34 inches, brown (10YR 5/3), mixed very coarse sand and gravel; single grain; loose when dry or moist; calcareous; gradual, wavy boundary.
IIC2—34 to 56 inches, light brownish-gray (10YR 6/2) coarse sand; single grain; loose when dry or moist; calcareous; gradual, wavy boundary.
IIC3—56 to 60 inches, yellowish-brown to pale-brown (10YR 5/4 to 10YR 6/3) gravel; single grain; loose when dry or moist; calcareous.

The thickness of the A1 horizon ranges from 8 to 14 inches, and the texture from sandy loam to loam. The thickness and degree of development of the B horizon vary. In places the C horizon contains stratified layers of sand and gravel or mixtures of sand and gravel. In many places there is, just below the B horizon, a thin horizon that is leached of free carbonates and is neutral in reaction.

Fairhaven Series

The Fairhaven series consists of nearly level or undulating, moderately well drained or well drained soils that are underlain by sand at a depth of 24 to 36 inches. These soils developed under mixed forest and grass vegetation in old glacial drainageways that became blocked. The blocking caused temporary ponding of the glacial melt water and deposition of silty sediments on the outwash sand. These soils occur on the edges of the till bumps near St. Cloud and Becker.

These soils are not closely associated with any particular soils in the county but occur in the same general area as Hayden soils. The acreage is small. Fairhaven soils have a lighter colored surface layer than Wadena soils, which are underlain by sand and gravel.

Profile of a Fairhaven silt loam, light-colored variant, in a cultivated field in the SW¼SW¼SW¼ sec. 27, T. 34 N., R. 28 W.

Ap—0 to 8 inches, very dark gray (10YR 3/1) silt loam; massive, breaking to medium crumb structure; very friable when moist; neutral; clear, wavy boundary.
A2—8 to 11 inches, dark grayish-brown (10YR 4/2) silt loam; moderate, thick, platy structure; friable when moist, slightly sticky and slightly plastic when wet; neutral; clear, wavy boundary.
B1—11 to 20 inches, dark yellowish-brown (10YR 4/4) silt loam; moderate, very fine, subangular blocky structure; friable when moist, sticky and plastic when wet; neutral; gradual, wavy boundary.
B2—20 to 27 inches, unevenly mottled dark yellowish-brown (10YR 4/4), yellowish-brown (10YR 5/6), and light olive-brown (2.5YR 5/4) silt loam; dark-brown (7.5YR 4/4) root channels; weak, very fine, subangular blocky structure; friable when moist, slightly sticky and slightly plastic when wet; neutral; clear, wavy boundary.
B3—27 to 35 inches, unevenly mottled light olive-brown (2.5Y 5/4) and grayish-brown (2.5Y 5/2) silt loam; dark-brown (7.5YR 4/2) root channels; strong, very fine, angular blocky structure; friable when moist, slightly sticky and plastic when wet; calcareous; clear, wavy boundary.
IIC1—35 to 42 inches, light yellowish-brown (2.5YR 6/4) fine sand; many, medium, distinct, pale-brown (10YR 6/3), yellowish-brown (10YR 5/4), and brown (10YR 4/3) mottles; loose both when dry and when moist; calcareous; gradual, wavy boundary.

IIC2—42 to 46 inches, pale-brown (10YR 6/3) fine sand; common, medium, distinct, light yellowish-brown (2.5Y 6/4 and 10YR 6/4) mottles; single grain; loose both when dry and when moist; calcareous; gradual, wavy boundary.

IIC3—46 to 54 inches, unevenly mottled dark grayish-brown (10YR 4/2) and grayish-brown (10YR 5/2) fine sand; single grain; loose both when dry and when moist; calcareous.

The A horizon ranges from silt loam to very fine sandy loam in texture, and from very dark gray to very dark grayish brown or black in color.

Hayden Series

The Hayden series consists of gently sloping to steep, well-drained soils. These soils developed under deciduous trees in calcareous, gray glacial till. They occur in the northwestern and central parts of the county.

Hayden soils are associated with Braham, Dundas, Emmert, and Milaca soils. They differ from Braham soils in having a surface layer of fine sandy loam or loam instead of loamy fine sand and a subsoil of clay loam instead of silty clay loam. They are better drained than Dundas soils and have browner colors in the subsoil. Hayden soils developed in gray, calcareous till and are calcareous in the substratum. Milaca soils, in contrast, developed in red, noncalcareous till and are slightly acid in the substratum.

Profile of Hayden fine sandy loam in a virgin area in the SW¼NE¼NW¼ sec. 18, T. 34 N., R. 28 W.

A1—0 to 4 inches, very dark grayish-brown (10YR 3/2) fine sandy loam; massive, breaking to weak, very fine, angular blocky structure; very friable when moist; medium acid; smooth, abrupt boundary.

A2—4 to 16 inches, dark grayish-brown (10YR 4/2) fine sandy loam; weak, coarse, angular blocky structure; friable when moist, slightly hard when dry; slightly acid; clear, wavy boundary.

B2—16 to 41 inches, dark yellowish-brown (10YR 4/4) clay loam; brown (10YR 4/3) clay films; white silt on some peds in uppermost 12 inches; strong to moderate, medium, subangular blocky structure; firm when moist, sticky and very plastic when wet, hard when dry; slightly acid; gradual, wavy boundary.

C1—41 to 51 inches, light olive-brown (2.5Y 5/4) loam to clay loam; light-gray (2.5Y 7/2) lime threads; massive; friable when moist, sticky and plastic when wet; calcareous.

The texture of the A horizon ranges from loam to fine sandy loam and, in spots, to loamy fine sand. The thickness of this horizon ranges from 12 to 20 inches. The depth to the calcareous C horizon ranges from 36 to 60 inches. In places clay film covers the peds throughout the B horizon. The color of the film ranges from brown (10YR 4/3) through dark grayish brown (10YR 4/2) to dark brown (7.5YR 4/4). Only in spots in the uppermost part of the B horizon are peds coated with white silt. Organic staining occurs on fracture planes and root channels, to a depth of 60 inches in some places.

Hubbard Series

The Hubbard series consists of excessively drained or somewhat excessively drained soils that are predominantly nearly level or undulating. Small areas are rolling to steep. These soils developed under tall prairie grasses in medium and coarse outwash sand that was deeply leached. For the most part, they occur in the southern and western parts of the county.

Hubbard soils are associated with Estherville and Salida soils but are underlain by leached sand instead of sand and gravel. They have a thicker, darker colored surface layer than Zimmerman soils and are coarser textured.

Profile of Hubbard loamy sand in a cultivated field in the SW¼NE¼SW¼ sec. 30, T. 33 N., R. 27 W.

Ap—0 to 9 inches, black (10YR 2/1) loamy sand with inclusions and variegations of very dark brown (10YR 2/2); weak, coarse, angular blocky structure; slightly hard when dry, friable when moist; medium acid; abrupt, smooth boundary.

A3—9 to 15 inches, very dark brown (10YR 2/2) loamy sand grading to dark brown (7.5Y 3/2) with depth; weak, coarse, angular blocky structure; slightly hard when dry, friable when moist; medium acid; clear, wavy boundary.

B2—15 to 23 inches, dark-brown (10YR 4/3) to dark yellowish-brown (10YR 4/4) loamy sand; weak, coarse, angular blocky structure; very friable when moist; medium acid; gradual, wavy boundary.

C1—23 to 29 inches, dark-brown (10YR 4/3) sand and coarse sand; single grain; loose both when dry and when moist; medium acid; diffuse boundary.

C2—29 to 32 inches, dark-brown (10YR 4/3) coarse sand and fine gravel (40 percent gravel); single grain; loose both when dry and when moist; clear, wavy boundary.

C3—32 to 60 inches, brown (10YR 5/3) coarse sand; single grain; loose both when dry and when moist; slightly acid; clear, wavy boundary.

C4—60 inches +, dark grayish-brown (10YR 4/2) to brown (10YR 5/3) coarse sand; single grain; loose both when dry and when moist; calcareous.

The texture of the A horizon ranges from loamy sand through loamy fine sand to light sandy loam. The thickness ranges from 10 to 16 inches. Strata of sand and gravel or gravelly bands 1 inch to 10 inches thick are common in the lower part of the profile. The depth of leaching is ordinarily about 5 feet but ranges from 3 to 8 feet.

Profile of Hubbard sandy loam in a virgin site in the woods in the NW¼SW¼ sec. 8, T. 34 N., R. 29 W.

O1—1½ inches to 0, organic matter, roots, and grasses.

A11—0 to 9 inches, black (10YR 2/1) sandy loam; weak, fine to medium, crumb structure; very friable when moist; medium acid; gradual, wavy boundary.

A12—9 to 14 inches, very dark brown (10YR 2/2) sandy loam; massive, breaking to weak, very fine, subangular blocky structure; friable when moist; medium acid; gradual, wavy boundary.

B2—14 to 20 inches, dark-brown (7.5YR 3/2 to 10YR 4/3) sandy loam; massive, breaking to weak, very fine, subangular blocky structure; strongly acid; clear, wavy boundary.

C1—20 to 24 inches, dark-brown (10YR 3/3 to 4/3) very coarse sand and fine gravel; single grain; loose when dry and moist; strongly acid; clear, wavy boundary.

C2—24 to 28 inches, brown (10YR 4/3) loamy sand and a few pebbles; single grain; very friable when moist; strongly acid; clear, wavy boundary.

C3—28 to 54 inches, dark grayish-brown (10YR 4/2) sand and coarse sand; single grain; loose both when dry and when moist; neutral; clear, wavy boundary.

C4—54 to 65 inches, grayish-brown (10YR 5/2) gravelly coarse sand; single grain; calcareous.

The thickness of the A horizon ranges from 10 to 16 inches. The depth to sand ranges from 12 to 24 inches. The depth of leaching is ordinarily about 60 inches but ranges from 36 to 80 inches.

Isanti Series

The Isanti series consists of level or slightly depressional, very poorly drained soils. These soils developed under aquatic grasses and sedges in deep, noncalcareous, fine outwash sand partly sorted by wind action. They occur on broad flats, in slight depressions, and around the edges of some of the peat bogs in the central and northern parts of the county.

Isanti soils are members of the catena that includes the excessively drained Zimmerman soils and the somewhat poorly drained Lino soils. They have a thicker, darker colored A1 horizon than Lino soils and are gleyed below the A horizon. Isanti soils are also associated with Hubbard soils. In these places their profile is coarser textured than the one described.

Profile of Isanti loamy fine sand in a depression in an abandoned field in the NE¼NE¼NE¼ sec. 28, T. 35 N., R. 28 W.

O1—1 inch to 0, dried grass, grass roots, and organic matter.
A1—0 to 11 inches, black (10YR 2/1) loamy fine sand high in organic matter; weak, medium, crumb structure; very friable when moist; strongly acid; clear, wavy boundary.
ACg—11 to 18 inches. dark-gray (10YR 4/1) fine sand; single grain; medium acid; gradual, wavy boundary.
C1g—18 to 25 inches, grayish-brown (2.5Y 5/2) fine sand; single grain; loose both when dry and when moist; medium acid; gradual, wavy boundary.
C2g—25 to 36 inches, grayish-brown (2.5Y 5/2) fine sand; many, medium, distinct, yellowish-brown (10YR 5/6, 5/4) mottles; single grain; nonsticky when wet; strongly acid; clear, wavy boundary. Free water in this horizon.
C3g—36 to 42 inches, gray (10YR 5/1) sand; many, coarse, prominent, dark-brown (7.5YR 4/4) and strong-brown (7.5YR 5/6, 5/8) mottles; single grain; nonsticky when wet; strongly acid; gradual, wavy boundary. Free water in this horizon.
C4—42 to 48 inches, unevenly and very strongly mottled, dark-brown (7.5YR 4/4) and strong-brown (7.5YR 5/6, 5/8) coarse sand; single grain; nonsticky when wet; strongly acid. Free water in this horizon.

The surface layer ranges from loamy fine sand to sandy loam in texture and is generally high in organic-matter content. In places there is a layer of peat or muck up to 12 inches thick above the A1 horizon. If undrained, these soils are likely to be covered with water in spring and early in summer. The depth to the water table ranges from 0 to 30 inches.

Lino Series

The Lino series consists of somewhat poorly drained, nearly level or slightly undulating, deep sands. These soils developed under mixed forest and grass vegetation in wind- and water-sorted outwash of loose fine sand. They occur in the central and northern parts of the county.

Lino soils are associated with Hubbard soils and are members of the catena that includes the excessively drained Zimmerman soils and the very poorly drained Isanti soils. They are wetter than Zimmerman soils and are mottled throughout the profile. They have a thinner, lighter colored surface layer than Isanti soils.

Profile of Lino loamy fine sand in a cultivated field in the NE¼NE¼NE¼ sec. 28, T. 35 N., R. 28 W.

Ap—0 to 7 inches, very dark grayish-brown (10YR 3/2) loamy fine sand; single grain; loose when dry or moist; strongly acid; clear, wavy boundary.
C1—7 to 16 inches, dark grayish-brown (10YR 4/2) to brown (10YR 4/3) fine sand; many, medium, distinct, dark-brown (7.5YR 4/4) and dark reddish-brown (5YR 3/4) mottles; single grain; loose when dry or moist; medium acid; gradual, wavy boundary.
C2—16 to 38 inches, brown (10YR 5/3) fine sand; many, coarse, prominent, strong-brown (7.5YR 5/6, 5/8), brown (7.5YR 4/4), and yellowish-red (5YR 4/6, 5/8) mottles; single grain; loose when dry or moist; medium acid; gradual, wavy boundary.
C3—38 to 48 inches, strong-brown (7.5YR 5/6) fine sand; few, fine, distinct, gray (10YR 5/1) mottles; single grain; loose when dry or moist; medium acid.

The surface layer becomes darker colored and the subsoil grayer as the soil approaches a poorly drained condition. Conversely, the upper part of the subsoil becomes less distinctly mottled as the soil approaches a moderately well drained condition. In areas where these soils are associated with Hubbard soils, the A1 horizon is generally darker colored than the one in the profile described, and the sand is somewhat coarser.

Profile of Lino loamy fine sand, loamy substratum, in a virgin site in the woods in the SE¼NW¼NW¼ sec. 31, T. 34 N., R. 26 W.

A1—0 to 6 inches, black (10YR 2/1) loamy fine sand or fine sandy loam; high content of organic matter; many white sand grains; moderate, medium and coarse, granular structure; very friable when moist; slightly acid; gradual, wavy boundary.
AC—6 to 15 inches, very dark gray (10YR 3/1) loamy fine sand with inclusions of dark gray (10YR 4/1); few, fine, faint, very dark brown (10YR 2/2) mottles; massive, breaking to weak, medium, crumb structure; very friable when moist; gradual, irregular boundary.
C1—15 to 28 inches, grayish-brown (10YR 5/2) fine sand; many, medium, distinct, brown (10YR 5/3) and yellowish-brown (10YR 5/4, 5/8) mottles; single grain; loose when dry or moist; neutral; diffuse, wavy boundary.
C2g—28 to 34 inches, gray (10YR 5/1) to grayish-brown (10YR 5/2) fine sand; many, medium, distinct, yellowish-brown (10YR 5/4, 5/6, 5/8) and strong-brown (7.5YR 5/6, 5/8) mottles; single grain; loose when dry or moist; neutral; few black (5Y 2/1) manganese concretions; gradual, wavy boundary.
C3g—34 to 40 inches, gray (10YR 5/1) fine sand; many, medium, distinct, yellowish-brown (10YR 5/4, 5/8) and dark yellowish-brown (10YR 4/4) mottles; weak, medium, platy structure; loose when dry or moist; neutral; clear, wavy boundary.
IIC4g—40 to 43 inches, gray (5Y 5/1) fine sandy loam; many, medium, prominent, yellowish-brown (10YR 5/4, 5/6, 5/8) mottles; moderate, medium, platy structure; very friable when moist, slightly sticky and slightly plastic when wet; neutral; clear, wavy boundary.
IIIC5g—43 to 50 inches, gray (5Y 5/1) sand; many, medium, prominent, yellowish-brown (10YR 5/4, 5/8) and strong-brown (7.5YR 5/8) mottles; single grain; loose when dry or moist; neutral; clear, wavy boundary.
IVC6g—50 to 62 inches, olive-gray (5Y 5/2) clay loam; many, fine, distinct, light olive-brown (2.5Y 5/4, 5/6), olive-brown (2.5Y 4/4), and bluish-gray (5B 6/1) mottles; massive; firm when moist, sticky and plastic when wet; calcareous; many white lime concretions.

The depth to the medium-textured bands or underlying material ranges from 18 to more than 54 inches.

Milaca Series

The Milaca series consists of nearly level to steep, well-drained soils that developed under mixed hardwoods in noncalcareous, red glacial till. The till is mod-

erately coarse textured to medium textured and contains many rocks and cobblestones. These soils have a fragipan that extends through the lower part of the B horizon and the upper part of the C horizon. They occur on ground moraines. The largest acreage is in the northern part of the county in Santiago and Blue Hill Townships. There are smaller acreages north of Becker and in the hilly, morainic area northeast of Elk River.

Milaca soils are members of the catena that includes the moderately well drained Mora soils, the somewhat poorly drained Ronneby soils, and the poorly drained Adolph soils. Milaca soils generally occupy a higher topographic position than Mora soils and lack mottling in the A horizon and the upper part of the B horizon. In a few spots they are associated with Hayden soils, from which they differ in having a reddish subsoil and a noncalcareous C horizon.

Profile of Milaca fine sandy loam in a cultivated area in the NE¼NW¼ sec. 9, T. 35 N., R 29 W.

Ap—0 to 7 inches, very dark grayish-brown (10YR 3/2) fine sandy loam; weak, very fine, subangular blocky structure; friable when moist; medium acid; abrupt, smooth boundary.

A2—7 to 19 inches, brown (10YR 5/3 to 7.5YR 5/4) fine sandy loam to loamy fine sand; many cobblestones and stones; very weak, thin, platy structure breaking to weak, fine, crumb; friable when moist; slightly acid; clear, wavy boundary.

Bx—19 to 52 inches, dark reddish-brown (5YR 3/4) heavy sandy loam; moderate, medium and thin, platy structure breaking to moderate, coarse, subangular blocky; firm when moist, hard when dry; slightly acid; diffuse, wavy boundary.

C—52 to 124 inches, reddish-brown (5YR 4/3) heavy sandy loam; moderate, medium and thin, platy structure; firm when moist, hard when dry; slightly acid.

In virgin sites these soils have a thin, very dark gray (10YR 3/1) or very dark brown (10YR 2/2) A horizon. The texture of the Ap horizon ranges from loam to sandy loam, and that of the A2 horizon from sandy loam to loamy sand. The degree of stoniness varies, but stones and boulders are common both on the surface and in the profile. If the soil is moist, the upper and lower limits of the fragipan are indistinct. If the soil is dry, the pan is indurated and is clearly evident, particularly in road cuts. In places there are faint mottles in the lower part of the B horizon or in the upper part of the C horizon. There are a few pockets of sand and gravel in the substratum.

Mora Series

The Mora series consists of nearly level or gently sloping, moderately well drained soils that developed under native hardwoods in noncalcareous, reddish glacial till. The till is moderately coarse textured to medium textured and contains many rocks and cobblestones. These soils have a fragipan that extends through the lower part of the B horizon and the upper part of the C horizon. The largest acreage occurs in the northern part of the county in Santiago and Blue Hill Townships.

Mora soils are closely associated with the somewhat poorly drained Ronneby soils and the well-drained Milaca soils. They are members of the catena that includes the Milaca, Ronneby, and Adolph soils. They occupy a higher topographic position than Ronneby soils, and they have a less grayish A2 horizon and are less mottled than those soils. They have mottles in the lower part of the A horizon and in the B horizon; Milaca soils, in comparison, are mottled in the lower part of the B horizon and upper part of the C horizon.

Profile of Mora loam in a cultivated field in the SW¼NW¼NW¼ sec. 11, T. 35 N., R. 28 W.

Ap—0 to 5 inches, very dark gray (10YR 3/1) to very dark brown (10YR 2/2) loam; moderate, thin to medium, platy structure; friable when moist; strongly acid; clear, wavy boundary.

A2—5 to 16 inches, dark grayish-brown (10YR 4/2) sandy loam; common, fine, faint, dark-gray (10YR 4/1) and grayish-brown (10YR 5/2) mottles; weak to moderate, thin, platy structure; friable when moist; strongly acid; clear, wavy boundary.

B1—16 to 20 inches, brown (7.5YR 5/4) loam; common, fine, faint, yellowish-brown (10YR 5/6) and brown (10YR 5/3) mottles; strong, fine, angular blocky structure; firm when moist, hard when dry; medium acid; clear, wavy boundary.

Bx—20 to 30 inches, reddish-brown (5YR 4/4) heavy sandy loam; many, fine, distinct, reddish-brown (5YR 4/4) and yellowish-red (5YR 4/8) mottles; moderate, thin to medium, platy structure; firm when moist; medium acid; gradual, wavy boundary.

Cx—30 to 42 inches, reddish-brown (5YR 4/4) sandy loam; many, medium, prominent, reddish-brown (5YR 5/4), yellowish-red (5YR 4/8), and dark reddish-brown (5YR 3/4) mottles; massive; sticky and slightly plastic when wet; medium acid.

The surface layer ranges from loam to sandy loam in texture. The Ap horizon ranges from very dark brown (10YR 2/2) to very dark grayish brown (10YR 3/2).

Pomroy Series

The Pomroy series consists of nearly level or undulating, well drained or moderately well drained soils that are underlain by well-sorted sand at a depth of 24 to 42 inches. These soils developed under forest vegetation in noncalcareous, red glacial till. They have a fragipan in the underlying till. They occur in the northern part of the county near Santiago, and also as scattered areas along the Benton County line.

Pomroy soils are associated with Mora and Zimmerman soils and generally occur in a transition zone between these two soils. They differ from Mora soils in texture. They overlie red glacial till instead of deep sand like that under Zimmerman soils, or gray glacial till or lacustrine material, like that under Braham soils.

Profile of Pomroy loamy fine sand in a cultivated field in the SE¼NE¼NW¼ sec. 14, T. 35 N., R. 28 W.

Ap—0 to 8 inches, very dark grayish-brown (10YR 3/2) loamy fine sand; single grain; loose both when dry and when moist; strongly acid; gradual, wavy boundary.

A3—8 to 12 inches, mixed dark-brown (10YR 3/3), very dark grayish-brown (10YR 3/2), and dark grayish-brown (10YR 4/2) loamy sand; single grain; loose both when dry and when moist; medium acid; gradual, wavy boundary.

C1—12 to 28 inches, mixed dark grayish-brown (10YR 4/2) and dark-brown (10YR 4/3) loamy sand; common, medium, faint, brown (10YR 5/3) mottles; single grain; loose both when dry and when moist; slightly acid; gradual, wavy boundary.

C2—28 to 34 inches, mottled dark grayish-brown (10YR 4/2), brown (10YR 4/3), and dark-brown (7.5YR 4/4 and 3/3) loamy sand grading to sandy loam in lower part; many pebbles and cobblestones; many, medium, distinct mottles; single grain; very friable to loose when moist; medium acid; clear, wavy boundary.

IIC3x—34 to 48 inches, reddish-brown (5YR 4/4) fine sandy loam; many, fine and medium, prominent, dark reddish-brown (5YR 3/4), reddish-brown (5YR 5/4 and 5/3), reddish-gray (5YR 5/2), and yellowish-red (5YR 4/6 and 5/6) mottles; massive, breaking to weak, thick, platy structure; firm when moist; medium acid.

The texture of the uppermost 12 inches ranges from sandy loam to loamy fine sand. The color of the A horizon ranges from very dark brown (10YR 2/2) to very dark grayish brown (10YR 3/2). Mottles are lacking on the well-drained steeper slopes but are prominent in the lower part of the profile in some nearly level areas.

Ronneby Series

The Ronneby series consists of somewhat poorly drained soils that developed under native hardwoods in noncalcareous, red glacial till. The till is moderately coarse textured or medium textured and contains many rocks and cobblestones. These soils occur in nearly level areas and on the lower slopes of ground moraines. The largest acreage is in the northern part of the county, mainly in Santiago and Blue Hill Townships.

Ronneby soils are closely associated with the moderately well drained Mora soils and the poorly drained Adolph soils. They are members of the catena that includes the Milaca, Mora, and Adolph soils. They occupy a lower topographic position than Mora soils, have a grayer A2 horizon, and are more mottled. They occupy a higher topographic position than Adolph soils, are dryer, and have a thinner, lighter colored surface layer.

Profile of Ronneby loam in a pasture, partly cleared, in an oak forest in the SW¼SW¼ sec. 6, T. 35 N., R. 27 W.

O2—1 inch to 0, black (10YR 2/1) duff.

A1—0 to 3 inches, black (10YR 2/1) loam; common, fine, faint, very dark brown (10YR 2/2) mottles; moderate, very fine, subangular blocky structure; friable when moist, slightly sticky and slightly plastic when wet; medium acid; clear, wavy boundary.

A21g—3 to 8 inches, dark-gray (10YR 4/1) sandy loam; many, fine, distinct, dark-brown (7.5YR 3/2 and 4/2) mottles; strong, medium, platy structure; friable when moist, slightly sticky and slightly plastic when wet; medium acid; clear, wavy boundary.

A22g—8 to 16 inches, grayish-brown (10YR 5/2) light sandy loam; many, medium, prominent, dark-brown (7.5YR 3/2) mottles; moderate, medium, platy structure; friable when moist, slightly sticky and slightly plastic when wet; medium acid; clear, wavy boundary.

Bx—16 to 30 inches, dark-brown (7.5YR 4/3) fine sandy loam; many, medium, distinct, reddish-brown (5YR 4/4) and reddish-gray (5YR 5/2) mottles; moderate, medium to thick, platy structure; hard when dry, friable to firm when moist, sticky and plastic when wet; strongly acid; gradual, wavy boundary.

Cx—30 to 42 inches, reddish-brown (5YR 4/3) heavy sandy loam; many cobblestones; many, medium, prominent, dark-brown (7.5YR 4/4), dark reddish-brown (5YR 3/4), and reddish-gray (5YR 5/2) mottles; massive, breaking to weak, thin, platy structure; hard when dry, firm when moist, sticky and plastic when wet; strongly acid.

The texture of the A1 horizon ranges from loam to light sandy loam. The thickness ranges from 2 to 5 inches. The matrix color of the A21 horizon ranges from dark gray (10YR 4/1) to gray or grayish brown (10YR 5/1, 5/2). In places the mottles in the A21 horizon are brown (10YR 4/3). Cobblestones make up 5 to 20 percent of the soil mass. The substratum is generally acid but is neutral in some places.

Salida Series

The Salida series consists of nearly level to hilly, excessively drained soils. These soils are 12 to 18 inches thick over sand and gravel that is calcareous at a depth of 24 to 36 inches. They developed under prairie grasses in calcareous, gravelly glacial outwash. They occur in the southern and western parts of the county, mainly in the townships adjacent to the Mississippi River.

The Salida soils in this county are outside the central concept for the series because of the varying depth to free carbonates. The maximum allowable depth within the central concept is 29 inches.

Salida soils are closely associated with Hubbard and Estherville soils. As compared with Hubbard soils, they are underlain by calcareous gravel and sand instead of deeply leached sand. They have a coarser textured surface layer than Estherville soils and are shallower over gravel.

Profile of Salida loamy sand in a cultivated field in the SE¼SE¼SW¼ sec. 17, T. 33 N., R. 28 W.

Ap—0 to 6 inches, black (10YR 2/1) loamy sand; weak, medium and fine, granular structure; very friable when moist; medium acid; clear, wavy boundary.

A3—6 to 10 inches, very dark grayish-brown (10YR 3/2) loamy sand; weak, medium and fine, granular structure; very friable when moist; slightly acid; clear, wavy boundary.

B2—10 to 16 inches, dark-brown (10YR 3/3 to 4/3) gravelly loamy sand; single grain; loose both when dry and when moist; slightly acid; gradual, wavy boundary.

IIC1—16 to 30 inches, dark-brown (10YR 3/3 to 4/3) sand and coarse sand; single grain; loose both when dry and when moist; neutral; gradual, wavy boundary.

IIC2—30 to 39 inches, dark grayish-brown (10YR 4/2) to brown (10YR 5/3) gravel; single grain; loose both when dry and when moist; calcareous; gradual, wavy boundary.

IIC3—39 to 43 inches, grayish-brown (10YR 5/2) to pale-brown (10YR 5/3) sand; single grain; calcareous; loose both when dry and when moist; diffuse, wavy boundary.

IIC4—43 to 54 inches, grayish-brown (10YR 5/2) to pale-brown (10YR 6/3) sand and gravel; a few inclusions of yellowish brown (10YR 5/6); single grain; loose both when dry and when moist; calcareous.

The texture of the surface layer ranges from loamy sand to light sandy loam. The thickness of the A horizon ranges from 6 to 12 inches. In places the gravel is either mixed with sand or contains bands of sand at a depth of 18 to 36 inches. The depth to gravel and the depth of leaching vary.

Wadena Series

The Wadena series consists of nearly level, well-drained soils that are underlain by sand and gravel at a depth of 24 to 36 inches. These soils developed under prairie grasses in calcareous outwash. They occur on the outwash plain in the southern and western parts of the county, mainly in the townships adjacent to the Mississippi River.

Wadena soils are closely associated with Estherville and Hubbard soils. They have a finer textured solum than Estherville soils. They are underlain by sand and gravel; Hubbard soils are underlain by deeply leached sand.

Profile of Wadena loam in a cultivated field in the NW¼NE¼NE¼ sec. 32, T. 35 N., R. 30 W.

Ap—0 to 9 inches, black (10YR 2/1) loam; weak to moderate, fine, granular structure; friable when moist; medium acid; abrupt, smooth boundary.

B21—9 to 15 inches, dark-brown (7.5YR 3/2) light clay loam; weak to moderate, medium, blocky structure; friable when moist; medium acid; clear, wavy boundary.

B22—15 to 24 inches, dark-brown to brown (7.5YR 4/4) light clay loam; weak to moderate, medium, blocky structure; friable when moist; medium acid; clear, wavy boundary.

C1—24 to 31 inches, brown (10YR 4/3) gravel and sand; single grain; loose both when dry and when moist; medium acid; clear, wavy boundary.

C2—31 to 42 inches, yellowish-brown (10YR 5/4) gravel and sand; single grain; loose both when dry and when moist; calcareous.

The thickness of the surface layer ranges from 8 to 12 inches.

Zimmerman Series

The Zimmerman series consists of nearly level to steep, excessively drained soils. These soils developed under trees in deep, noncalcareous, loose, fine outwash sands that had been sorted by wind and water action. They occur in the central and northern parts of the county.

Zimmerman soils are members of the catena that includes the somewhat poorly drained Lino soils and the very poorly drained Isanti soils. They occupy a higher topographic position than Lino soils, are better drained, and lack mottles. They have a lighter colored surface layer and a finer texture throughout than have the Hubbard soils. The underlying material is finer textured than that of Braham soils.

Profile of Zimmerman loamy fine sand in a virgin site in the woods in the SW¼NW¼ sec. 17, T. 35 N., R. 28 W.

A1—0 to 3 inches, very dark grayish-brown (10YR 3/2) loamy fine sand; single grain; very friable to loose when moist; strongly acid; clear, wavy boundary.

A3—3 to 16 inches, dark yellowish-brown (10YR 3/4) fine sand; single grain; loose when moist; strongly acid; gradual, wavy boundary.

B—16 to 30 inches, brown (10YR 4/3) fine sand; single grain; loose when moist; strongly acid; diffuse boundary.

C1—30 to 48 inches, brown (10YR 5/3) to yellowish-brown (10YR 5/4) fine sand; single grain; loose when moist; strongly acid; diffuse boundary.

C2—48 to 64 inches, light yellowish-brown (10YR 6/4) fine sand; single grain; loose when moist; medium acid; gradual, wavy boundary.

The texture of the A horizon ranges from loamy fine sand to fine sand. The thickness of the A3 horizon ranges from 8 to 24 inches. Near the fringes of till knolls and in the northeastern part of the county, lenses of very fine sandy loam or silt loam, ¼ inch to 2 inches thick, occur in the lower part of the profile. In some areas in the northeastern part of the county, the sandy substratum has a color hue of 7.5YR.

Additional Facts About the County

Sherburne County was established in 1856 by an act of the territorial legislature. It was named for Moses Sherburne, a territorial judge of the Supreme Court.

Most of the early settlers were Scandinavian, German, and Canadian. The population was 723 in 1860. The population had increased to 7,281 by 1900, to 10,456 by 1940, and to 12,861 by 1960. It is about equally divided between urban and rural areas.

Trading centers are conveniently located within the county and in large centers nearby. Packing plants in St. Cloud and South St. Paul provide markets for livestock. There are grain elevators at Clear Lake, Elk River, Becker, Big Lake, and Zimmerman. The Rural Electrification Administration operates an atomic-powered generating plant at Elk River.

Nearly all farms have electricity, and most farms have telephone service. Natural gas is available in some parts of the county.

Near Elk River is the farm home of Oliver Hudson Kelly, the founder and first secretary of the National Grange. It is now owned by the Minnesota Historical Society.

Agriculture

Sherburne County has always been largely agricultural. In 1963, there were 760 farms in the county, and the average size of farms was about 232 acres.

Corn, soybeans, alfalfa-brome mixtures, oats, and rye are the crops most commonly grown. Wheat and potatoes were crops of considerable importance in the early 1900's. Potato yields had declined by 1940 but are now increasing as a result of irrigation. In 1900, approximately 18,883 acres was in wheat and 17,531 acres was in wild hay. Neither soybeans nor alfalfa was grown. By 1963, wheat production had dropped to 300 acres, but the acreage in soybeans totaled 18,900, and the acreage in alfalfa, 16,724.

Dairy cattle, beef cattle, and poultry are important in the economy of the county. The number of dairy cows is decreasing, and the number of beef cattle is increasing. In 1963, there were 20,700 head of cattle and calves, of which 6,700 were milk cows. Milk production totaled 56 million pounds.

Many farmers supplement their incomes with off-the-farm employment. At the time of the 1959 census, 429 farmers reported working off the farm. Of this number, 342 reported an off-the-farm income that exceeded the value of the agricultural products they sold.

In 1941, the Soil Conservation Service established a wind erosion control project on 30 farms in the Clear Lake area. The Sherburne Soil and Water Conservation District was organized in 1944. By 1964, more than 600 miles of field windbreaks, largely of pine trees, had been planted, and 10 to 12 million trees had been planted in Christmas-tree plantations and forest plantings.

Physiography and Drainage

Postglacial deposits dominate the landscape of Sherburne County. The outwash plain ordinarily has smooth relief, but there are a few iceblock lakes, depressions, peat bogs, and sand dunes. Several islands of glacial till project through the outwash plain, and a belt of morainic hills extends across the eastern part of the county from Elk River to Lake Fremont. The highest

elevations in the county are along the crests of these hills and ridges, which rise abruptly as much as 100 feet or more above the sand plain.

Blue Hill, which is about 7 miles northwest of Zimmerman, is the highest elevation in the county. It rises to 1,090 feet above sea level. The lowest elevation, approximately 860 feet above sea level, occurs along the Mississippi River just south of Elk River.

Approximately 90 percent of the county is drained by the Elk and St. Francis Rivers and their tributaries. These rivers enter the county from the north, flow southeastward, and empty into the Mississippi River near the town of Elk River The rest of the county is drained by streams that flow northward and eastward.

Climate [5]

The climate of Sherburne County is typical of areas in the central part of the North American continent. Winters are cold. Summers are warm and pleasant. The interaction between cold air from the north and warm, moist air from the south causes marked daily changes in both temperature and precipitation. The wide range of temperature and precipitation during the year is shown in table 7.

The mean temperature during December, January, and February is 13.3° F. The temperature drops to between —20° and —30° on several days each winter, but such temperatures usually occur with light winds and low humidity and are not so severe as one might expect. The mean temperature during June, July, and August is 68.2°. Hot spells are uncommon. Temperatures of 100° or higher have occurred only twice in the past 20 years. The probability of specified temperatures in spring and fall are shown in table 8. For example, in 5 out of 10 years, a temperature of 32° or lower can be expected after May 7. In fall, there is a 50-percent probability of a temperature of 32° or lower on September 27. The latest recorded occurrence of a freezing temperature in spring is June 9, and the earliest in fall is September 3. The freeze-free period is long enough (*2*, *3*) that such crops as corn, soybeans, small grain, and vegetables generally have time to reach maturity.

Precipitation is well distributed throughout the growing season. About 17.4 inches, or 60 percent of the total annual precipitation, falls during the period from May through September. Tables 9 and 10 show the probability of receiving specified amounts of precipitation for 1-week and 3-week periods during the growing season

[5] By JOSEPH H. STRUB, Jr., State climatologist, U.S. Weather Bureau.

TABLE 7.--TEMPERATURE AND PRECIPITATION DATA

[All data from records kept at Weather Bureau Airport Station, St. Cloud, Minn.]

Month	Temperature				Precipitation				
	Average daily maximum	Average daily minimum	2 years in 10 will have at least 4 days with--		Average total	1 year in 10 will have--		Days with snow cover of 1 inch or more	Average depth of snow on days with snow cover
			Maximum temperature equal to or higher than--	Minimum temperature equal to or lower than--		Less than--	More than--		
	°F.	°F.	°F.	°F.	In.	In.	In.	No.	In.
January	21	0	39	-24	0.8	0.2	1.3	28	6
February	25	3	42	-18	.7	.2	1.6	26	8
March	37	17	53	-8	1.2	.4	2.1	22	8
April	54	32	75	19	2.0	.5	3.6	2	2
May	67	43	83	31	3.1	1.0	5.7	(1/)	0
June	77	53	91	42	3.9	2.0	8.5	0	0
July	83	58	96	48	3.1	1.3	5.8	0	0
August	81	56	93	46	2.9	.8	5.0	0	0
September	71	47	89	33	3.0	.8	5.0	0	0
October	59	35	75	22	1.6	.3	3.5	(1/)	0
November	38	20	56	0	1.4	.2	2.3	8	3
December	25	6	40	-15	.7	.1	1.7	17	5
Year	53	31	2/ 97	3/ -26	24.4	21.0	32.3	103	7

1/ Less than 0.5 day.

2/ Average annual highest temperature.

3/ Average annual lowest temperature.

TABLE 8.--PROBABILITY OF LOW TEMPERATURES IN SPRING AND IN FALL

[All data from records kept at Weather Bureau Airport Station, St. Cloud, Minn.]

Probability	Dates for given probability and temperature						
	16° F.	20° F.	24° F.	28° F.	32° F.	36° F.	40° F.
Spring:							
1 year in 10 later than-------	Apr. 12	Apr. 25	May 1	May 9	May 20	June 1	June 15
2 years in 10 later than------	Apr. 7	Apr. 18	Apr. 26	May 4	May 16	May 27	June 9
5 years in 10 later than------	Mar. 28	Apr. 6	Apr. 15	Apr. 24	May 7	May 19	May 29
Fall:							
1 year in 10 earlier than-----	Oct. 29	Oct. 19	Oct. 2	Sept. 25	Sept. 12	Sept. 4	Aug. 25
2 years in 10 earlier than----	Nov. 2	Oct. 23	Oct. 8	Oct. 1	Sept. 17	Sept. 9	Aug. 30
5 years in 10 earlier than----	Nov. 11	Nov. 1	Oct. 19	Oct. 11	Sept. 27	Sept. 19	Sept. 10

TABLE 9.--PROBABILITY OF SPECIFIED AMOUNTS OF PRECIPITATION IN SPECIFIED 1-WEEK PERIODS

[Interpolated from records at Minneapolis, Bird Island, and Pine River Dam]

Period beginning between--	Probability, in percent, of specified amounts of precipitation							
	None or trace	0.2 inch	0.4 inch	0.6 inch	0.8 inch	1 inch	1.4 inches	2 inches
April 26 and May 2----------	9	71	54	41	29	21	11	3
May 3 and May 9----------	11	69	55	43	34	26	17	7
May 10 and May 16----------	7	67	51	39	29	22	14	6
May 17 and May 23----------	6	78	64	50	39	30	18	7
May 24 and May 30----------	7	69	55	43	34	27	18	9
May 31 and June 6----------	7	70	61	54	48	43	37	27
June 7 and June 13----------	12	81	70	59	50	42	28	17
June 14 and June 20----------	6	79	70	53	44	36	23	14
June 21 and June 27----------	7	87	65	64	54	45	30	17
June 28 and July 4----------	10	80	75	56	46	39	26	14
July 5 and July 11----------	15	74	61	49	40	32	19	10
July 12 and July 18----------	9	67	51	40	32	25	16	8
July 19 and July 25----------	12	74	60	49	39	31	21	10
July 26 and August 1----------	16	67	52	39	30	22	13	5
August 2 and August 8----------	9	69	54	42	33	26	17	8
August 9 and August 15--------	7	73	58	26	37	30	19	10
August 16 and August 22-------	13	71	59	49	40	33	23	13
August 23 and August 29-------	22	64	51	41	33	26	17	9
August 30 and September 5-----	9	68	52	40	31	24	15	7
September 6 and September 12--	4	80	66	55	46	38	26	15
September 13 and September 19-	9	69	55	44	35	28	19	10
September 20 and September 26-	13	60	45	35	27	21	13	6
September 27 and October 3----	30	48	35	25	18	14	8	3

TABLE 10.--PROBABILITY OF SPECIFIED AMOUNTS OF PRECIPITATION IN SPECIFIED 3-WEEK PERIODS

[Interpolated from records at Minneapolis, Bird Island, and Pine River Dam]

Period beginning between--	Probability, in percent, of specified amounts of precipitation							
	None or trace	0.2 inch	0.4 inch	0.6 inch	0.8 inch	1 inch	1.4 inches	2 inches
March 1 and March 21	7	82	65	48	34	23	11	3
March 22 and April 11	2	86	72	60	50	41	28	15
April 12 and May 2	0	96	91	84	75	65	49	30
May 3 and May 23	0	99	97	93	89	83	70	50
May 24 and June 13	0	99	99	97	94	90	81	65
June 14 and July 4	0	100	99	98	95	92	83	68
July 5 and July 25	0	98	94	89	83	76	63	45
July 26 and August 15	0	98	95	89	83	77	64	46
August 16 and September 5	0	99	98	94	89	84	70	51
September 6 and September 26	0	99	97	93	88	83	71	53
September 27 and October 17	2	90	80	70	59	51	36	21
October 18 and November 7	4	83	71	59	50	41	28	16
November 8 and November 28	4	81	66	52	41	32	20	9
November 29 and December 19	4	70	45	27	16	10	30	1
December 20 and January 9	7	70	47	30	19	12	4	1
January 10 and January 30	2	82	56	35	21	12	4	1
January 31 and February 27	0	86	63	43	28	17	6	1

(*5*). At least a trace or more can be expected on about 100 days each year. Heavy rains of 1.1 inches per hour can be expected about once every 2 years. The heaviest rains occur as thunderstorms and are sometimes accompanied by hail and damaging winds. An average of 38 thunderstorms occur annually. In 1 out of 3 years, the first measurable snowfall occurs late in October. The last in spring is usually late in April; infrequently it is early in May.

Droughts, though infrequent, do occur. A drought day is defined as a day when there is an inadequate amount of moisture in the root zone. Table 11 (*6*) shows the probability of drought days at St. Cloud.

TABLE 11.--PROBABILITY OF DROUGHT DAYS

Probability	Minimum number of drought days per season if available moisture capacity 1/ is--				
	1 in.	3 in.	5 in.	7 in.	9 in.
10 percent--	83	66	57	46	43
20 percent--	77	54	43	33	29
30 percent--	72	44	34	26	18
40 percent--	68	37	26	19	10
50 percent--	64	30	19	11	2
60 percent--	61	23	10	5	0
70 percent--	57	16	3	0	0
80 percent--	53	8	0	0	0
90 percent--	46	0	0	0	0

1/ The amount of water a soil can hold and make available to plants. For the estimated water-holding capacity of the individual soils, by soil layers, see column "Available water capacity" in table 4.

Windspeeds range from 6.4 miles per hour in August to 9.8 miles per hour in April. The prevailing direction is southerly in summer and northerly in winter. Tornadoes are uncommon; only two were reported in the county during the period 1916 to 1965.

Noontime relative humidity ranges from 50 percent in May to 73 percent in December. During a typical year, there are 96 clear days, 108 partly cloudy days, and 161 cloudy days. Heavy fog is infrequent; fog can be expected on only 20 days out of the year.

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Glossary

Aggregate, soil. Many fine particles held in a single mass or cluster, as a clod, a crumb, a block, or a prism.

Alluvium. Soil material, such as sand, silt, or clay, that has been deposited on land by streams.

Calcareous soil. A soil containing sufficient calcium carbonate to effervesce (fizz) visibly when treated with dilute hydrochloric acid.

Catena. A sequence, or "chain," of soils on a landscape, developed from one kind of parent material but having different characteristics because of differences in relief and drainage.

Clay. As a soil separate, mineral soil particles that are less than 0.002 millimeter in diameter. As a soil textural class, soil material that is 40 percent or more clay, less than 45 percent sand, and less than 40 percent silt. (See also Texture, soil.)

Consistence, soil. The feel of the soil and the ease with which a lump can be crushed by the fingers. Terms commonly used to describe consistence are—

Loose.—Noncoherent; will not hold together in a mass.

Friable.—When moist, crushes easily under gentle pressure between thumb and forefinger and can be pressed together into a lump.

Firm.—When moist, crushes under moderate pressure between thumb and forefinger, but resistance is distinctly noticeable.

Plastic.—When wet, readily deformed by moderate pressure but can be pressed into a lump; will form a "wire" when rolled between thumb and forefinger.

Sticky.—When wet, adheres to other material, and tends to stretch somewhat and pull apart, rather than to pull free from other material.

Hard.—When dry, moderately resistant to pressure; can be broken with difficulty between thumb and forefinger.

Soft.—When dry, breaks into powder or individual grains under very slight pressure.

Cemented.—Hard and brittle; little affected by moistening.

Drift (geology). Material of any sort deposited by geological processes in one place after having been removed from another. *Glacial drift* consists of earth, sand, gravel, and boulders deposited by glaciers and by the streams and lakes associated with glaciers. It includes *glacial till,* which is not stratified, and *glacial outwash,* which is stratified.

Horizon, soil. A layer of soil, approximately parallel to the surface that has distinct characteristics produced by soil-forming processes.

Lacustrine deposit (geology). Material deposited in lake water and exposed by the lowering of the water level or elevation of the land.

Loam. The textural class name for soil having a moderate amount of sand, silt, and clay. Loam soils are 7 to 27 percent clay, 28 to 50 percent silt, and less than 52 percent sand. (See also Texture, soil.)

Mineral soil. Soil composed chiefly of mineral (inorganic) material and low in content of organic matter.

Moraine (geology). An accumulation of earth, stones, and other debris deposited by a glacier. Types of moraines are terminal, lateral, medial, and ground.

Mottling, soil. Irregularly marked with spots of different colors that vary in number and size. Mottling in soils usually indicates poor aeration and lack of drainage. Descriptive terms are as follows: Abundance—*few, common,* and *many;* size—*fine, medium,* and *coarse;* and contrast—*faint, distinct,* and *prominent.* The size measurements are these: *fine,* less than 5 millimeters (about 0.2 inch) in diameter along the greatest dimension; *medium,* ranging from 5 millimeters to 15 millimeters (about 0.2 to 0.6 inch) in diameter along the greatest dimension; and *coarse,* more than 15 millimeters (about 0.6 inch) in diameter along the greatest dimension.

Parent material. The unconsolidated mass of material from which the soil develops.

Permeability. The ability of the soil to transmit air or water Terms used to describe permeability are as follows: *very slow, slow, moderately slow, moderate, moderately rapid, rapid,* and *very rapid.*

Poorly graded soil (engineering). Soil material consisting mainly of particles that are nearly the same size. Because there is little difference in the size of the particles in poorly graded soil material, density can be increased only slightly by compaction.

Profile, soil. A vertical section of the soil through all its horizons and extending into the parent material.

Reaction, soil. The degree of acidity or alkalinity of a soil, expressed in pH values or words as follows:

	pH		pH
Extremely acid	Below 4.5	Neutral	6.6 to 7.3
Very strongly acid	4.5 to 5.0	Mildly alkaline	7.4 to 7.8
Strongly acid	5.1 to 5.5	Moderately alkaline	7.9 to 8.4
Medium acid	5.6 to 6.0	Strongly alkaline	8.5 to 9.0
Slightly acid	6.1 to 6.5	Very strongly alkaline.	9.1 and higher

Sand. As a soil separate, individual rock or mineral fragments 0.05 millimeter to 2.0 millimeters in diameter. Most sand grains consist of quartz, but sand may be any mineral composition. As a textural class, soil that is 85 percent or more sand and not more than 10 percent clay. (See also Texture, soil.)

Silt. As a soil separate, individual mineral particles that range in diameter from the upper limit of clay (0.002 millimeter) to the lower limit of very fine sand (0.05 millimeter). As a textural class, soil that is 80 percent or more silt and less than 12 percent clay. (See also Texture, soil.)

Solum. The upper part of a soil profile, above the parent material, in which the processes of soil formation are active. The solum in mature soil includes the A and B horizons. Generally, the characteristics of the material in these horizons are unlike those of the underlying material. The living roots and other plant and animal life characteristic of the soil are largely confined to the solum.

Structure, soil. The arrangement of primary soil particles into compound particles or clusters that are separated from adjoining aggregates and have properties unlike those of an equal mass of unaggregated primary soil particles. The principal forms of soil structure are—*platy* (laminated), *prismatic* (vertical axis of aggregates longer than horizontal), *columnar* (prisms with rounded tops), *blocky* (angular or subangular), and *granular. Structureless* soils are (1) *single grain* (each grain by itself, as in dune sand) or (2) *massive* (the particles adhering together without any regular cleavage, as in many claypans and hardpans).

Subsoil. Technically, the B horizon; roughly, the part of the profile below plow depth.

Substratum. Any layer beneath the solum, or true soil. It may refer either to the parent material or to other layers below the B horizon.

Surface soil. The soil ordinarily moved in tillage, or its equivalent in uncultivated soil, about 5 to 8 inches in thickness. The plow layer.

Texture, soil. The relative proportions of sand, silt, and clay particles in a mass of soil. The basic textural classes, in order of increasing proportion of fine particles, are *sand, loamy sand, sandy loam, loam, silt loam, silt, sandy clay loam, clay loam, silty clay loam, sandy clay, silty clay,* and *clay.* The sand, loamy sand, and sandy loam classes may be further divided by adding the words "coarse," "fine," or "very fine" to the name of the textural class.

Variant, soil. A soil that has properties sufficiently different from those of other known soils to justify a new series name, but of such limited geographic area that creation of a new series is not believed to be justified.

Wheel-track planting. Planting a crop at the time the soil is plowed, or soon after, without additional tillage operations to prepare a seedbed. Sometimes called plow planting.

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U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
MINNESOTA AGRICULTURAL EXPERIMENT STATION

GENERAL SOIL MAP
SHERBURNE COUNTY, MINNESOTA

SCALE IN MILES
1 0 1 2 3 4

SOIL ASSOCIATIONS

1 Hubbard-Estherville-Salida association: Nearly level to gently rolling, sandy soils over deeply leached sand or calcareous gravel

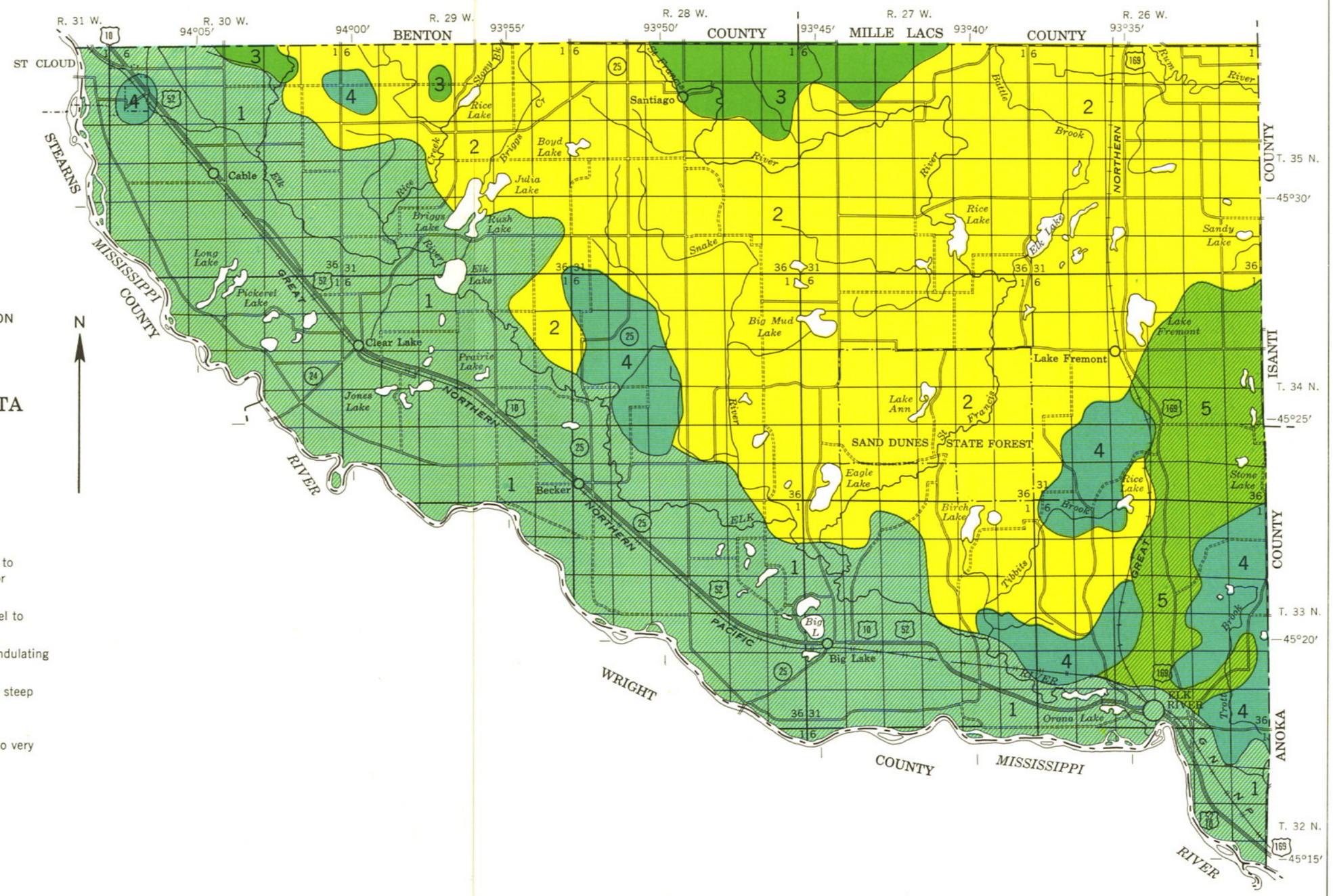
2 Zimmerman-Lino-Isanti-peat association: Nearly level to undulating, acid, windblown, sandy soils

3 Milaca-Mora-Ronneby association: Nearly level to undulating soils over slightly acid, red glacial till

4 Hayden-Braham-Emmert association: Undulating to steep soils over limy, gray glacial till mixed with red till or gravel or capped with fine sand

5 Burkhardt-Chetek-Emmert association: Undulating to very steep, shallow soils over acid gravel

December 1966



INDEX TO MAP SHEETS
SHERBURNE COUNTY, MINNESOTA

SCALE IN MILES

1 0 1 2 3 4

SOIL LEGEND

The first capital letter is the initial one of the soil name. A second capital letter, A, B, C, D, or E, shows the slope. Some symbols without a slope letter are for nearly level soils or land types, but some are for soils or land types that have a considerable range in slope. The number, 2 or 3, in a symbol indicates that the soil is eroded or severely eroded.

SYMBOL	NAME
Ad	Alluvial land
Af	Alluvial land, frequently flooded
Ap	Adolph loam
Bo	Beach sand
BeA	Becker loam, 0 to 2 percent slopes
BeB	Becker loam, 2 to 6 percent slopes
BrA	Braham loamy fine sand, 0 to 2 percent slopes
BrB	Braham loamy fine sand, 2 to 6 percent slopes
BrB2	Braham loamy fine sand, 2 to 6 percent slopes, eroded
BrC	Braham loamy fine sand, 6 to 12 percent slopes
BrC2	Braham loamy fine sand, 6 to 12 percent slopes, eroded
BrD	Braham loamy fine sand, 12 to 18 percent slopes
BuA	Burkhardt sandy loam, 0 to 2 percent slopes
BuB	Burkhardt sandy loam, 2 to 6 percent slopes
BuB2	Burkhardt sandy loam, 2 to 6 percent slopes, eroded
ChA	Chetek sandy loam, 0 to 2 percent slopes
ChB	Chetek sandy loam, 2 to 6 percent slopes
ChB2	Chetek sandy loam, 2 to 6 percent slopes, eroded
ChC	Chetek sandy loam, 6 to 12 percent slopes
ChC2	Chetek sandy loam, 6 to 12 percent slopes, eroded
ChC3	Chetek sandy loam, 6 to 12 percent slopes, severely eroded
Du	Dundas loam
EgC	Emmert gravelly loamy sand, 6 to 12 percent slopes
EgE	Emmert gravelly loamy sand, 12 to 35 percent slopes
ElA	Emmert loamy sand, 0 to 2 percent slopes
ElB	Emmert loamy sand, 2 to 6 percent slopes
ElB2	Emmert loamy sand, 2 to 6 percent slopes, eroded
ElC	Emmert loamy sand, 6 to 12 percent slopes
ElC2	Emmert loamy sand, 6 to 12 percent slopes, eroded
ElC3	Emmert loamy sand, 6 to 12 percent slopes, severely eroded
EmD	Emmert and Chetek soils, 12 to 18 percent slopes
EmD2	Emmert and Chetek soils, 12 to 18 percent slopes, eroded
EmE	Emmert and Chetek soils, 18 to 25 percent slopes
EmE2	Emmert and Chetek soils, 18 to 25 percent slopes, eroded
ErB2	Emmert–Hayden complex, 2 to 6 percent slopes, eroded
ErC2	Emmert–Hayden complex, 6 to 12 percent slopes, eroded
ErD2	Emmert–Hayden complex, 12 to 18 percent slopes, eroded
ErE2	Emmert–Hayden complex, 18 to 25 percent slopes, eroded
EsA	Estherville sandy loam, 0 to 2 percent slopes
EsA2	Estherville sandy loam, 0 to 2 percent slopes, wind eroded
EsB	Estherville sandy loam, 2 to 6 percent slopes
EsB2	Estherville sandy loam, 2 to 6 percent slopes, eroded
EsC	Estherville sandy loam, 6 to 12 percent slopes
EsC2	Estherville sandy loam, 6 to 12 percent slopes, eroded
FaA	Fairhaven silt loam, light–colored variant, 0 to 2 percent slopes
FaB	Fairhaven silt loam, light–colored variant, 2 to 6 percent slopes
HaA	Hayden fine sandy loam, 0 to 2 percent slopes
HaB	Hayden fine sandy loam, 2 to 6 percent slopes
HaB2	Hayden fine sandy loam, 2 to 6 percent slopes, moderately eroded
HaC	Hayden fine sandy loam, 6 to 12 percent slopes
HaC2	Hayden fine sandy loam, 6 to 12 percent slopes, moderately eroded
HaC3	Hayden fine sandy loam, 6 to 12 percent slopes, severely eroded
HaD	Hayden fine sandy loam, 12 to 18 percent slopes
HaD2	Hayden fine sandy loam, 12 to 18 percent slopes, moderately eroded
HaD3	Hayden fine sandy loam, 12 to 18 percent slopes, severely eroded
HaE	Hayden fine sandy loam, 18 to 35 percent slopes
HuA	Hubbard loamy sand, 0 to 2 percent slopes
HuA2	Hubbard loamy sand, 0 to 2 percent slopes, wind eroded
HuB	Hubbard loamy sand, 2 to 6 percent slopes
HuB2	Hubbard loamy sand, 2 to 6 percent slopes, eroded
HuB3	Hubbard loamy sand, 2 to 6 percent slopes, severely eroded
HuC	Hubbard loamy sand, 6 to 12 percent slopes
HuC2	Hubbard loamy sand, 6 to 12 percent slopes, eroded
HuC3	Hubbard loamy sand, 6 to 12 percent slopes, severely eroded
HuE	Hubbard loamy sand, 12 to 25 percent slopes
HuE2	Hubbard loamy sand, 12 to 25 percent slopes, eroded
HyA	Hubbard sandy loam, 0 to 2 percent slopes
HyA2	Hubbard sandy loam, 0 to 2 percent slopes, wind eroded
HyB	Hubbard sandy loam, 2 to 6 percent slopes
HyB2	Hubbard sandy loam, 2 to 6 percent slopes, eroded
HyC2	Hubbard sandy loam, 6 to 12 percent slopes, eroded
Is	Isanti loamy fine sand
LnA	Lino loamy fine sand, 0 to 2 percent slopes
LnA2	Lino loamy fine sand, 0 to 2 percent slopes, wind eroded
LnB	Lino loamy fine sand, 2 to 6 percent slopes
LsA	Lino loamy fine sand, loamy substratum, 0 to 2 percent slopes
Lw	Loamy wet land
Ma	Marsh
MfA	Milaca fine sandy loam, 0 to 2 percent slopes
MfB	Milaca fine sandy loam, 2 to 6 percent slopes
MfB2	Milaca fine sandy loam, 2 to 6 percent slopes, moderately eroded
MfC2	Milaca fine sandy loam, 6 to 12 percent slopes, eroded
MfD	Milaca fine sandy loam, 12 to 18 percent slopes
MfE	Milaca fine sandy loam, 18 to 25 percent slopes
MoA	Mora loam, 0 to 2 percent slopes
MoB	Mora loam, 2 to 6 percent slopes
Pa	Peat and muck, deep
Pc	Peat and muck, shallow, over loam
Pd	Peat and muck, shallow, over sand
Pn	Peat–Lino complex
PoA	Pomroy loamy fine sand, 0 to 2 percent slopes
PoB	Pomroy loamy fine sand, 2 to 6 percent slopes
Ro	Ronneby loam
SaB	Salida complex, 0 to 6 percent slopes
SaB2	Salida complex, 0 to 6 percent slopes, eroded
SaC	Salida complex, 6 to 12 percent slopes
SaC2	Salida complex, 6 to 12 percent slopes, eroded
SaE	Salida complex, 12 to 25 percent slopes
WaA	Wadena loam, 0 to 2 percent slopes
ZfE	Zimmerman fine sand, 12 to 25 percent slopes
ZmA	Zimmerman loamy fine sand, 0 to 2 percent slopes
ZmA2	Zimmerman loamy fine sand, 0 to 2 percent slopes, wind eroded
ZmB	Zimmerman loamy fine sand, 2 to 6 percent slopes
ZmB2	Zimmerman loamy fine sand, 2 to 6 percent slopes, eroded
ZmC	Zimmerman loamy fine sand, 6 to 12 percent slopes
ZmC2	Zimmerman loamy fine sand, 6 to 12 percent slopes, eroded

CONVENTIONAL SIGNS

WORKS AND STRUCTURES

Highways and roads
- Dual
- Good motor
- Poor motor
- Trail

Highway markers
- National Interstate
- U. S.
- State or county

Railroads
- Single track
- Multiple track
- Abandoned

Bridges and crossings
- Road
- Trail, foot
- Railroad
- Ferry (FY)
- Ford
- Grade
- R. R. over
- R. R. under
- Tunnel

Buildings
- School
- Church
- Station

Mines and Quarries
- Mine dump
- Pits, gravel or other

Power line

Pipeline

Cemetery

Dams

Levee

Tanks

Well, oil or gas

BOUNDARIES

- National or state
- County
- Township or range, U. S.
- Section line, corner, U. S.
- Reservation
- Land grant
- Small park, cemetery, airport

DRAINAGE

Streams, double-line
- Perennial
- Intermittent

Streams, single-line
- Perennial
- Intermittent
- Crossable with tillage implements
- Not crossable with tillage implements
- Unclassified

Canals and ditches (CANAL)

Lakes and ponds
- Perennial
- Intermittent

Wells, water (flowing)

Spring

Marsh or swamp

Wet spot

Alluvial fan

Drainage end

RELIEF

Escarpments
- Bedrock
- Other

Prominent peak

Depressions

	Large	Small
Crossable with tillage implements		
Not crossable with tillage implements		
Contains water most of the time		

SOIL SURVEY DATA

- Soil boundary and symbol (Dx)
- Gravel
- Stony, very stony
- Rock outcrops
- Chert fragments
- Clay spot
- Sand spot
- Gumbo or scabby spot
- Made land
- Severely eroded spot
- Blowout, wind erosion
- Gully
  - Not crossable with tillage implements
- Wind erosion, severe
- Short steep slope
- Small area of high lime soil (A)
- Sand dunes (S.D.)
- Borrow pit (B. P.)

Soil map constructed 1966 by Cartographic Division, Soil Conservation Service, USDA, from 1963 aerial photographs. Controlled mosaic based on Minnesota plane coordinate system, south zone, Lambert conformal conic projection, 1927 North American datum.


(Joins lower right)
R. 31 W.
BEAVER ISLAND
MISSISSIPPI RIVER
STEARNS COUNTY
13
24
T. 35 N.
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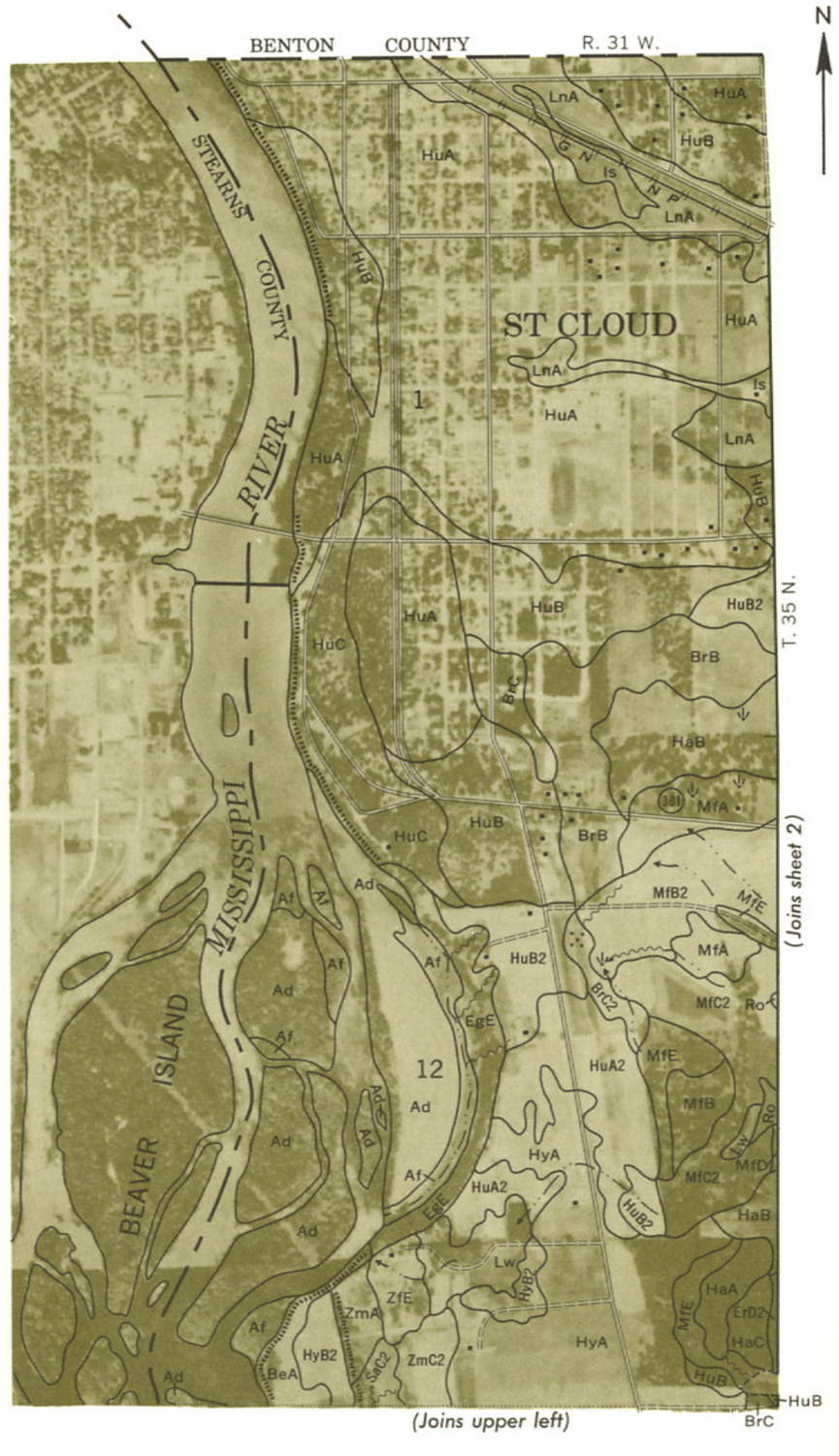
(Joins sheet 22)


BENTON COUNTY
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STEARNS COUNTY
RIVER
MISSISSIPPI
ST CLOUD
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BEAVER ISLAND
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(10)


N
MILLE LACS COUNTY
R. 26 W.
T. 35 N.
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(Joins sheet 11)
(Joins sheet 20)
NORTHERN
GREAT
Battle
Brook
6
5
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ZmA
ZmA2
ZmB
ZmB2
ZmC
ZmC2
LnA
Is
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BeA
EgE


R. 26 W.
MILLE LACS COUNTY
ISANTI COUNTY
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T. 35 N.
RUM RIVER
RUM RIVER
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(Joins sheet 21)

12


N
(Joins sheet 2)
R. 30 W.
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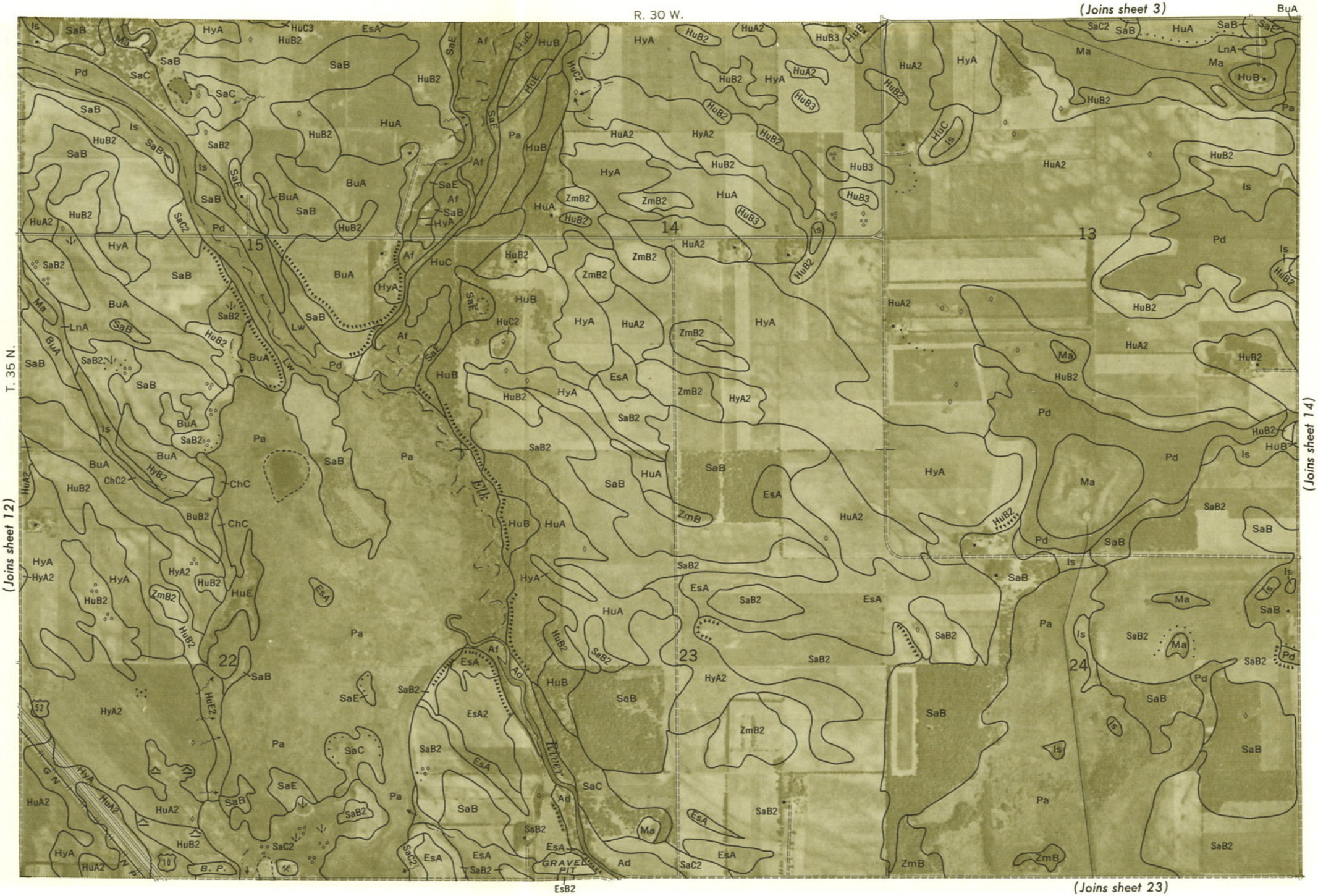
(Joins sheet 13)
T. 35 N.
(Joins sheet 22)
GRAVEL PIT
QUARRY
GREAT NORTHERN
NORTHERN PACIFIC
Cable
16
17
18
19
20
21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13
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15
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23
24
Elk
River
GRAVEL PIT
B. P.
GN
NP

(14)

N

(Joins sheet 4)

R. 29 W.

T. 35 N.

(Joins sheet 13)

(Joins sheet 15)

(Joins sheet 24)

18 17 16

19 20 21

Rice Creek

Rice Creek

Af Creek

GRAVEL PIT

SHERBURNE COUNTY, MINNESOTA — SHEET NUMBER 15

15

N

R. 29 W.

(Joins sheet 5)

T. 35 N.

(Joins sheet 14)

(Joins sheet 16)

(Joins sheet 25)

BRIGGS LAKE

JULIA LAKE

BOYD LAKE

Briggs Creek

16

N

(Joins sheet 6)

R. 28 W.

T. 35 N.

BOYD LAKE

18

17

16

19

20

21

(Joins sheet 15)

(Joins sheet 17)

(Joins sheet 26)


N
R. 28 W.
T. 35 N.
(Joins sheet 7)
(Joins sheet 16)
(Joins sheet 18)
(Joins sheet 27)
St Francis River
13
14
15
22
23
24
ZmA
ZmA2
ZmB
ZmB2
ZmC
ZmC2
LnA
Is
Pa
Af
Ma
PoA
PoB
MfB
MfB2
MfC2
ChB
ChB2
Ro
Lw
MoA
MoB
Ap
Pd
Pn

SHERBURNE COUNTY, MINNESOTA — SHEET NUMBER 18

(18)

N

(Joins sheet 8)

R. 27 W.

ST FRANCIS RIVER

18 17 16

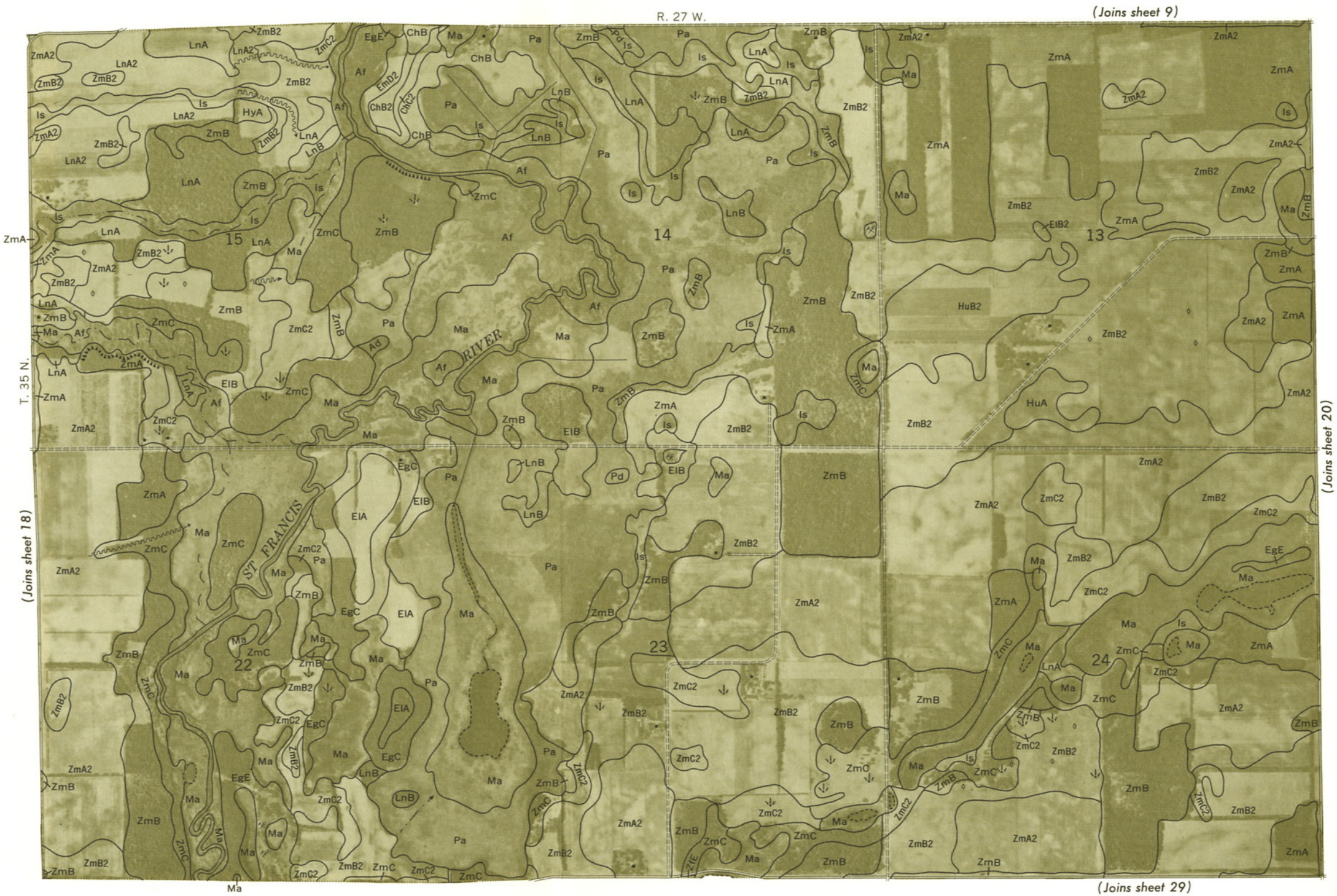
19 20 21

T. 35 N.

(Joins sheet 17)

(Joins sheet 19)

(Joins sheet 28)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T. 35 N.
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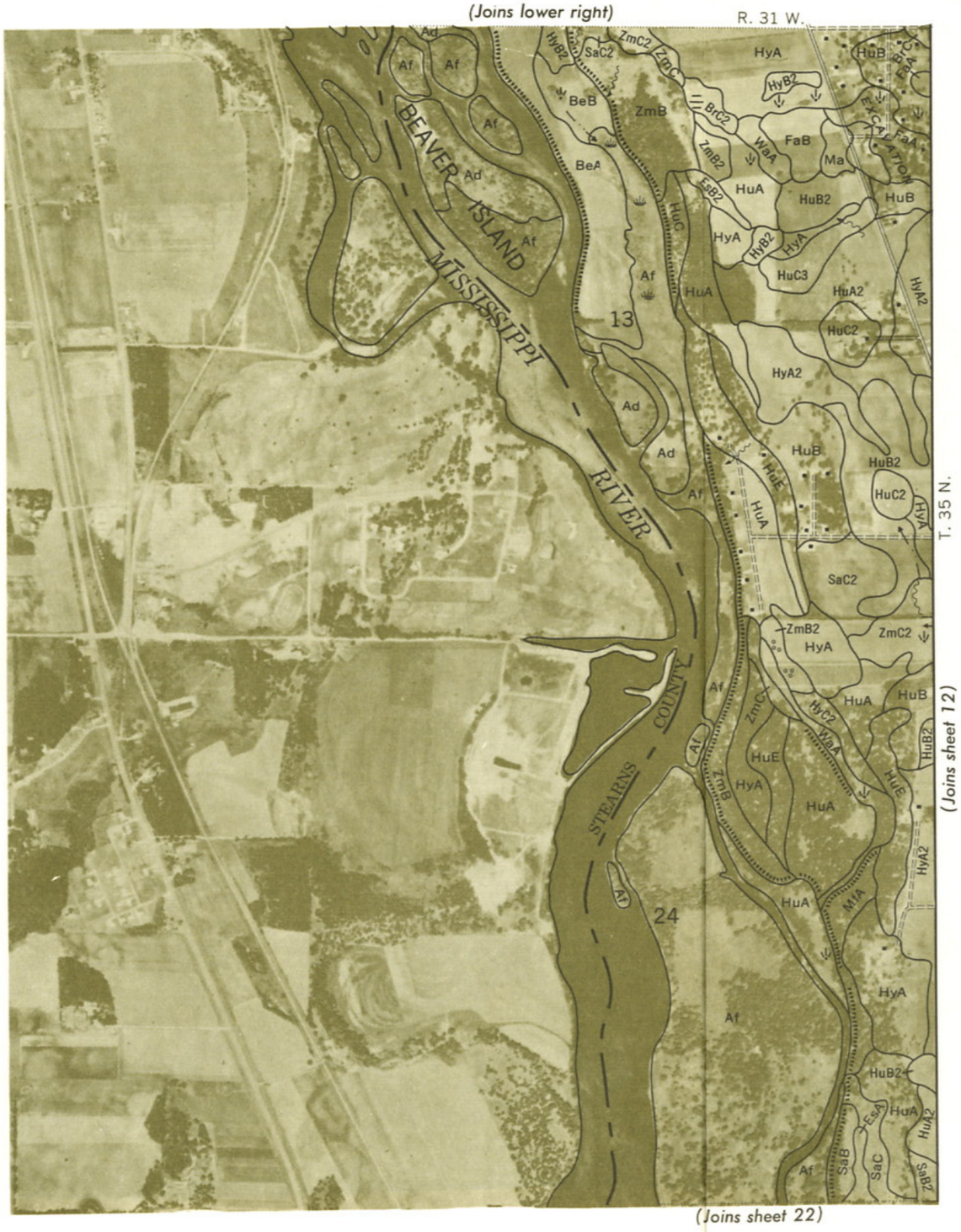
N
ST FRANCIS RIVER
15
14
13
22
23
24
ZmA
ZmA2
ZmB
ZmB2
ZmC
ZmC2
LnA
LnA2
LnB
Ma
Pa
Af
Is
ChB
ChB2
ChC2
EgE
EgC
EmD2
HyA
Ad
EIB
EIA
Pd
HuA
HuB2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STEARNS COUNTY
13
24
T. 35 N.
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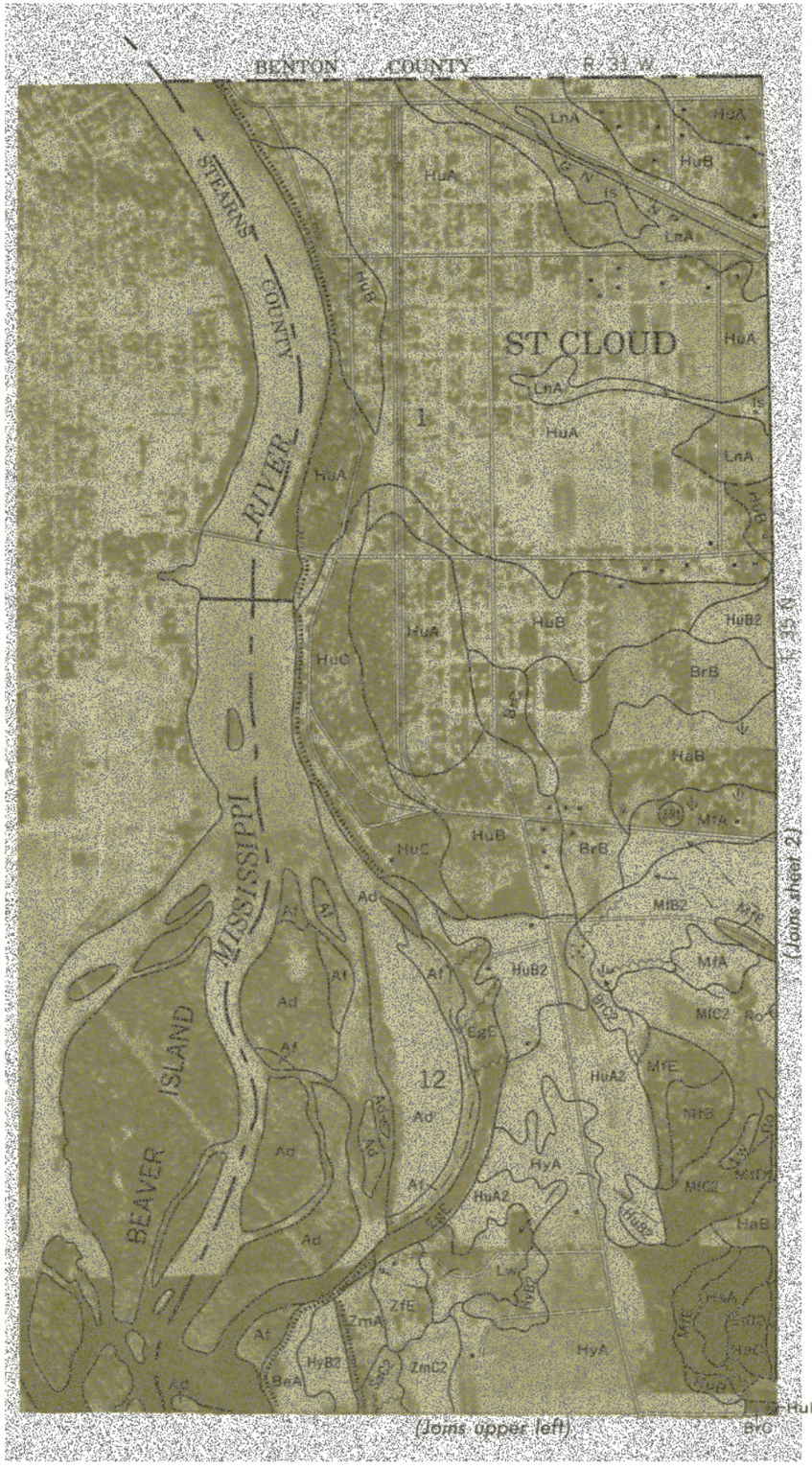
BENTON COUNTY
R. 31 W.
STEARNS COUNTY
MISSISSIPPI RIVER
BEAVER ISLAND
ST CLOUD
1
12
T. 35 N.
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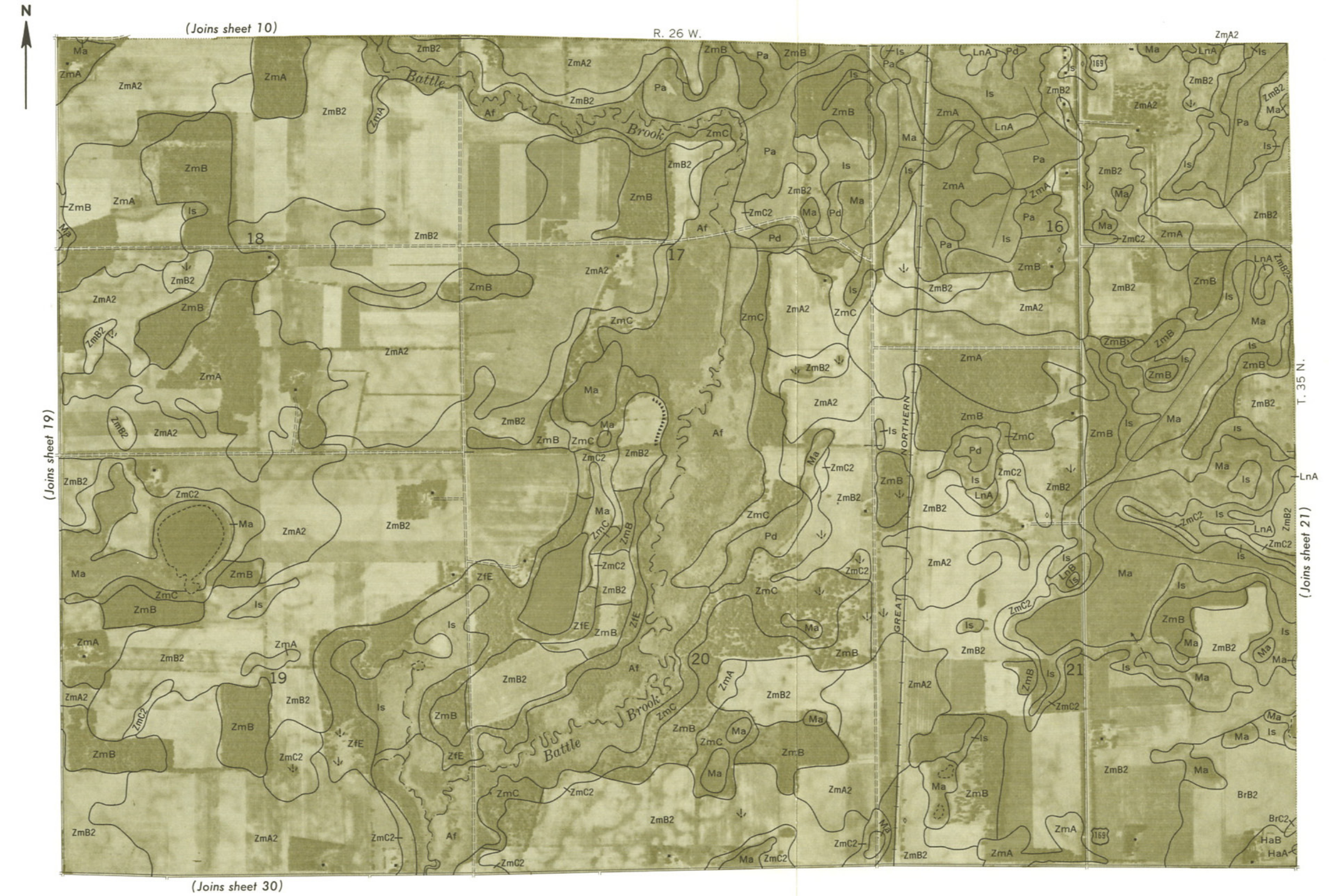
N


N
BENTON COUNTY
R. 30 W.
T. 35 N.
(Joins sheet 1)
(Joins sheet 3)
(Joins sheet 12)
GRAVEL PIT
GRANITE QUARRIES
STATE REFORMATORY
GREAT NORTHERN
NORTHERN PACIFIC
6
5
4
7
8
9


N
(Joins sheet 10)
R. 26 W.
(Joins sheet 19)
(Joins sheet 21)
T. 35 N.
(Joins sheet 30)
Battle Brook
Battle Brook
NORTHERN GREAT
18
17
16
19
20
21
ZmA
ZmA2
ZmB
ZmB2
ZmC
ZmC2
Af
Pa
Ma
Is
Pd
LnA
ZfE
BrB2
BrC2
HaB
HaA
169

SHERBURNE COUNTY, MINNESOTA — SHEET NUMBER 21

21

N

R. 26 W.

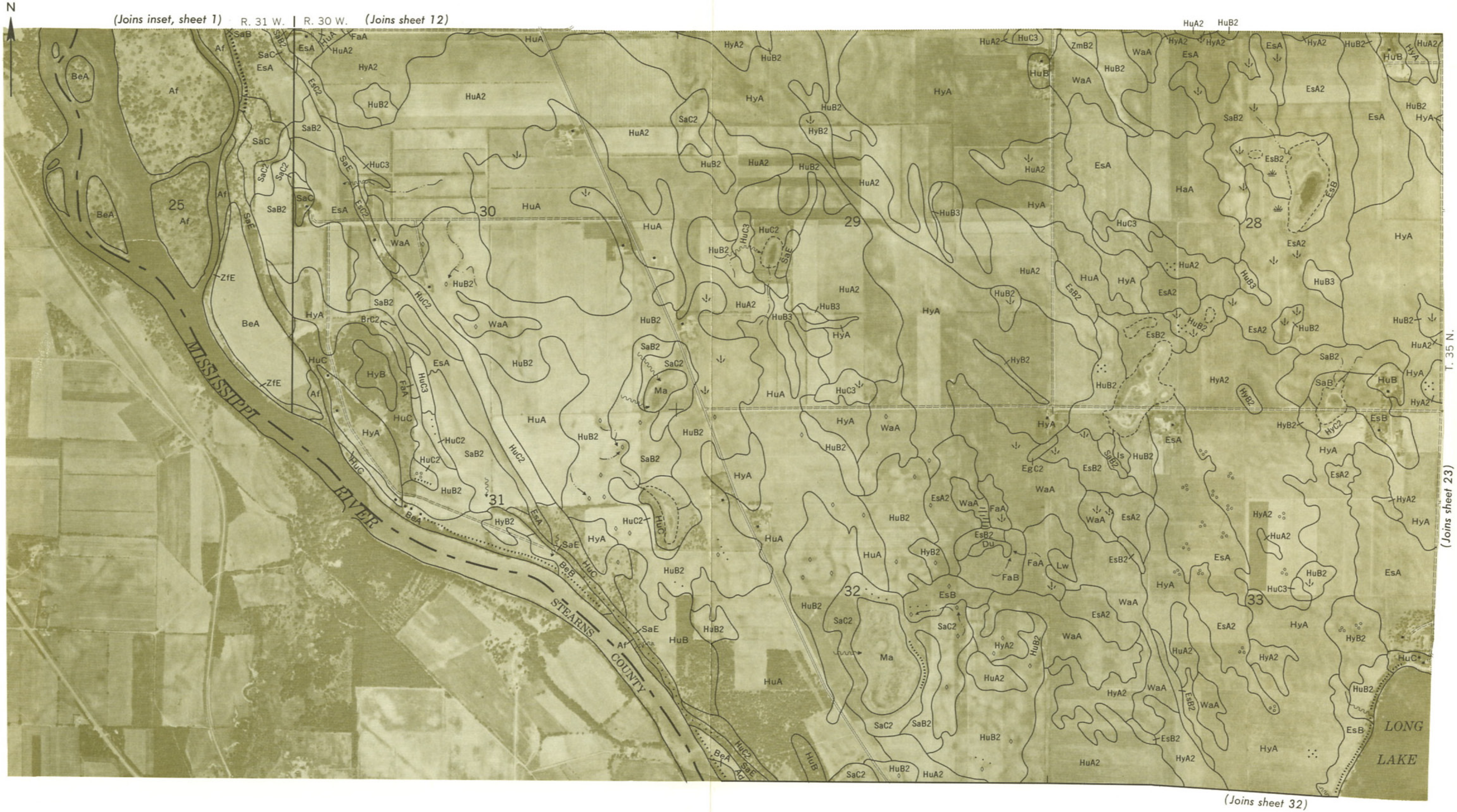
(Joins sheet 11)

T. 35 N.

ISANTI COUNTY

(Joins sheet 20)

(Joins sheet 31)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R. 31 W.
R. 30 W.
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T. 35 N.
(Joins sheet 23)
(Joins sheet 32)
MISSISSIPPI
RIVER
STEARNS
COUNTY
LONG
LAKE
25
30
29
28
31
32
33

SHERBURNE COUNTY, MINNESOTA — SHEET NUMBER 23

N

R. 30 W.

(Joins sheet 13)

T. 35 N.

(Joins sheet 22)

(Joins sheet 24)

(Joins sheet 33)

GREAT NORTHERN

NORTHERN PACIFIC

Elk River

ROUND LAKE

LONG LAKE

PICKEREL LAKE

CATER L

25 26 27 34 35 36


N
(Joins sheet 14)
R. 29 W.
(Joins sheet 23)
(Joins sheet 25)
(Joins sheet 34)
T. 35 N.
BRIGGS LAKE
ELK LAKE
RICE CREEK
ELK RIVER
ELK RIVER
28
29
30
31
32
33


R. 29 W.
(Joins sheet 15)
T. 35 N.
(Joins sheet 24)
(Joins sheet 26)
(Joins sheet 35)
N
JULIA LAKE
BRIGGS LAKE
RUSH LAKE
LILLY CREEK
ELK LAKE
25
26
27
34
35
36

N

(Joins sheet 16)

R. 28 W.

T. 35 N.

(Joins sheet 25)

(Joins sheet 27)

(Joins sheet 36)

Snake River

30 29 28 31 32 33 25

ZmB ZmB2 ZmA ZmA2 ZmC LnA LnA2 LnB Is Pd Pa Ma Pc


N
R. 28 W.
T. 35 N.
(Joins sheet 17)
(Joins sheet 26)
(Joins sheet 28)
(Joins sheet 37)
Jim Lake
River
Snake
Krager School
Durgin Slough
BLOWOUT
27
26
25
34
35
36
ZmA
ZmA2
ZmB
ZmB2
ZmC
ZmC2
LnA
Ma
Pa
Pd
Is
LhA

SHERBURNE COUNTY, MINNESOTA — SHEET NUMBER 28

28

N

(Joins sheet 18)

R. 27 W.

T. 35 N.

(Joins sheet 27)

(Joins sheet 29)

(Joins sheet 38)

30 29 28 31 32 33

Blue Hill

GALBRAITH CEMETERY

Durgin Slough

Beergerson Slough

SHERBURNE COUNTY, MINNESOTA — SHEET NUMBER 29

29

N

R. 27 W.

(Joins sheet 19)

T. 35 N.

(Joins sheet 28)

(Joins sheet 30)

(Joins sheet 39)

ST FRANCIS RIVER

RICE LAKE

ELK LAKE

BATTLE BROOK

Beergerson Slough

27 26 25 34 35 36


BENTON COUNTY
R. 30 W.
N
T. 35 N.
Haven Church
Elk River
(Joins sheet 2)
(Joins sheet 4)
(Joins sheet 13)

30

N

(Joins sheet 20)

R. 26 W.

(Joins sheet 29)

(Joins sheet 31)

T. 35 N.

(Joins sheet 40)

LAKE

ELK

GOOSE LAKE

DIANN LAKE

Little Diann Lake

HELENE LAKE

CANTLIN LAKE

BATTLE BROOK

NORTHERN

GREAT

28

29

30

31

32

33

R. 26 W

N

T. 35 N.

(Joins sheet 30)

(Joins sheet 21)

(Joins sheet 41)

ISANTI COUNTY

SANDY LAKE

27 26 25 34 35 36

32

N

R. 30 W.

(Joins sheet 42)

WRIGHT COUNTY

MISSISSIPPI RIVER

(Joins sheet 51)

R. 30 W.

(Joins sheet 22)

MISSISSIPPI RIVER

LONG LAKE

PICKEREL LAKE

STEARNS COUNTY

T. 34 N.

(Joins sheet 33)

N

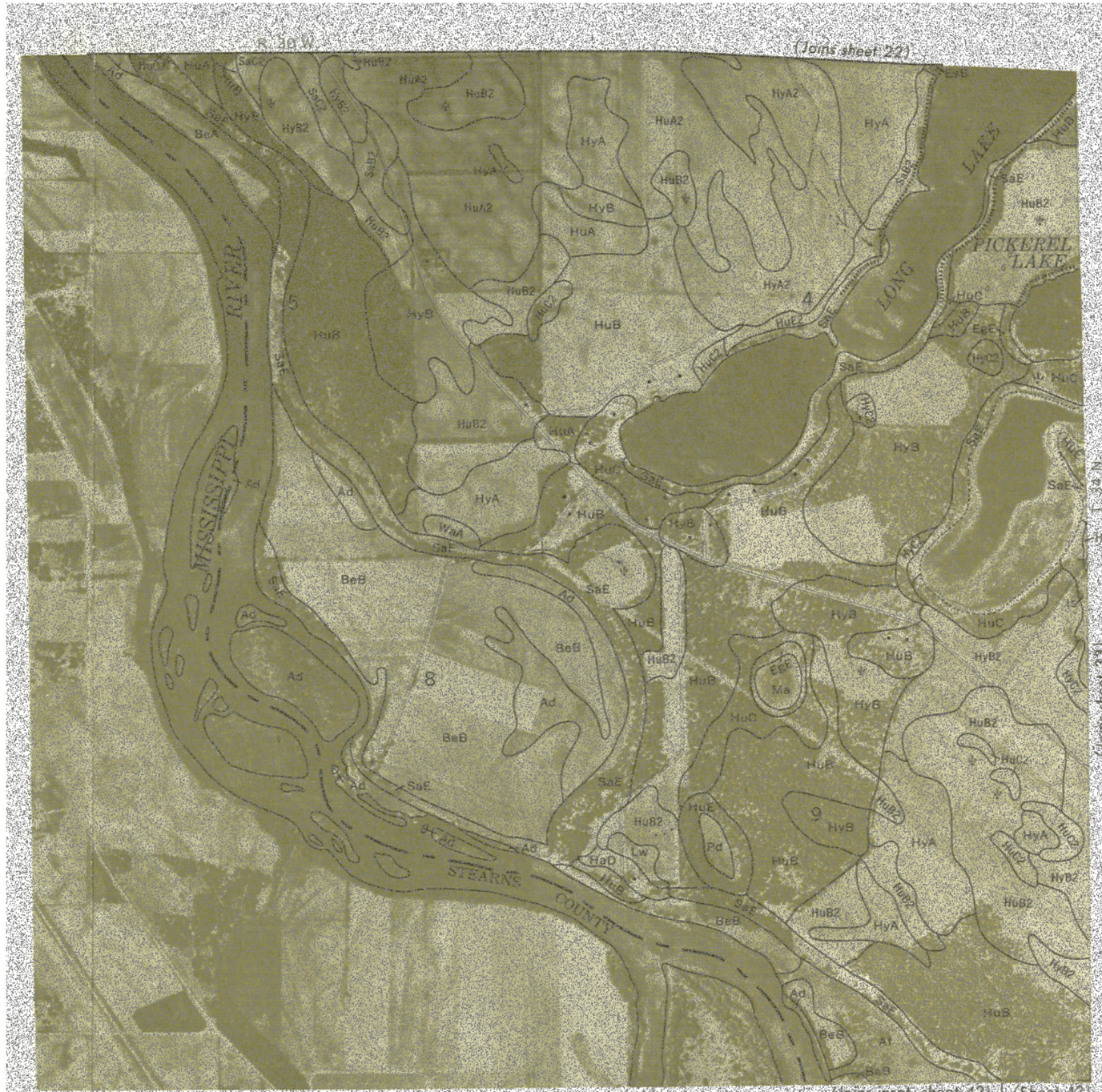
R. 30 W.

(Joins sheet 42)

(Joins sheet 51)

R. 30 W.

(Joins sheet 27)



(Joins inset sheet 42) | (Sheet 42)

(Joins sheet 33)


N
R. 30 W.
(Joins sheet 23)
T. 34 N.
(Joins sheet 32)
(Joins sheet 34)
(Joins sheet 42)
PICKEREL LAKE
CATER LAKE
STICKNEY LAKE
CLEAR LAKE
GREAT NORTHERN
NORTHERN PACIFIC
1
2
3
10
11
12

SHERBURNE COUNTY, MINNESOTA — SHEET NUMBER 34

34

N

(Joins sheet 24)

R. 29 W.

T. 34 N.

(Joins sheet 33)

(Joins sheet 35)

(Joins sheet 43)

ELK LAKE

EILERS LAKE

Clear Lake

G N

N P

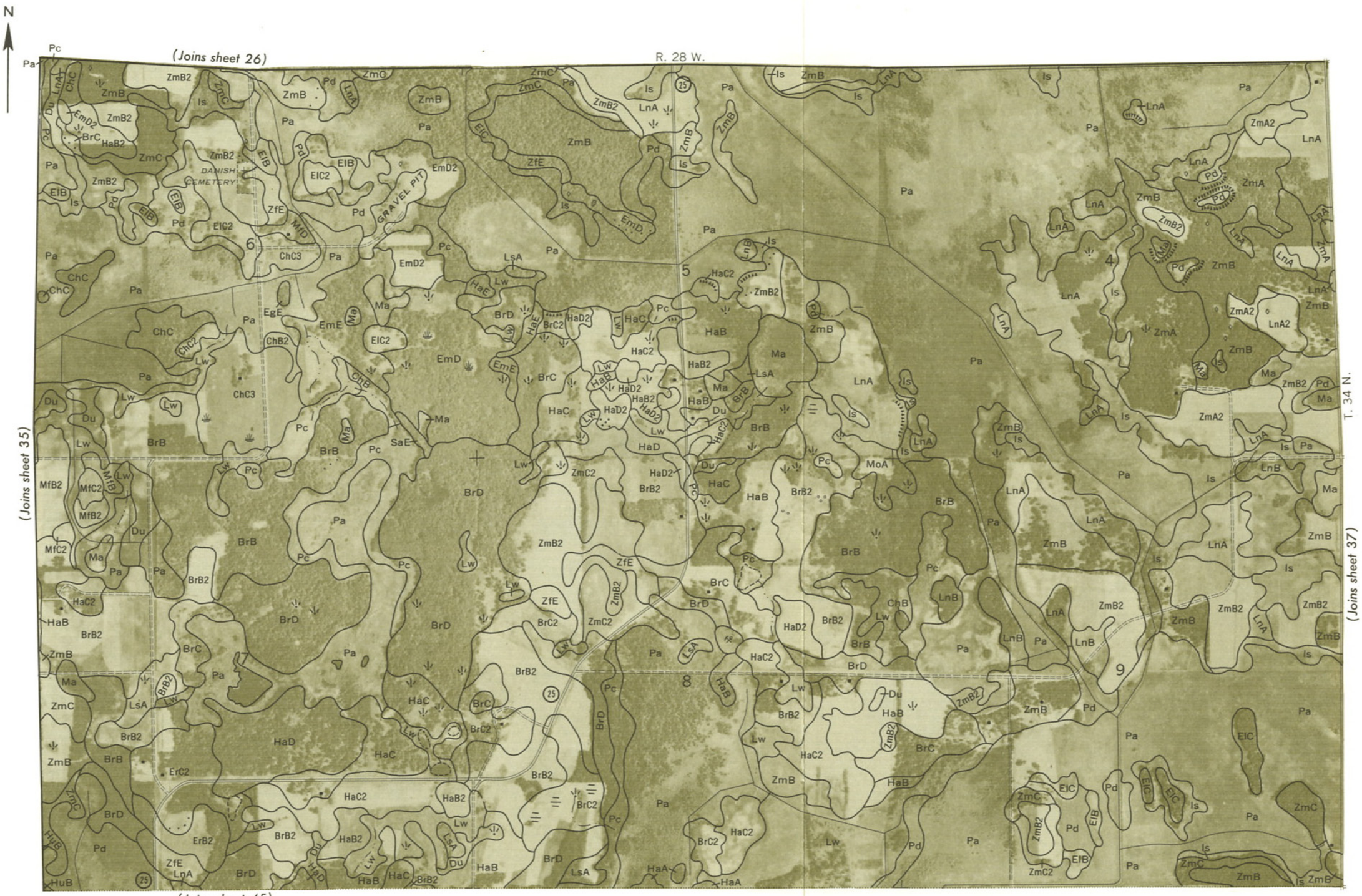
B. P.

10

52

94

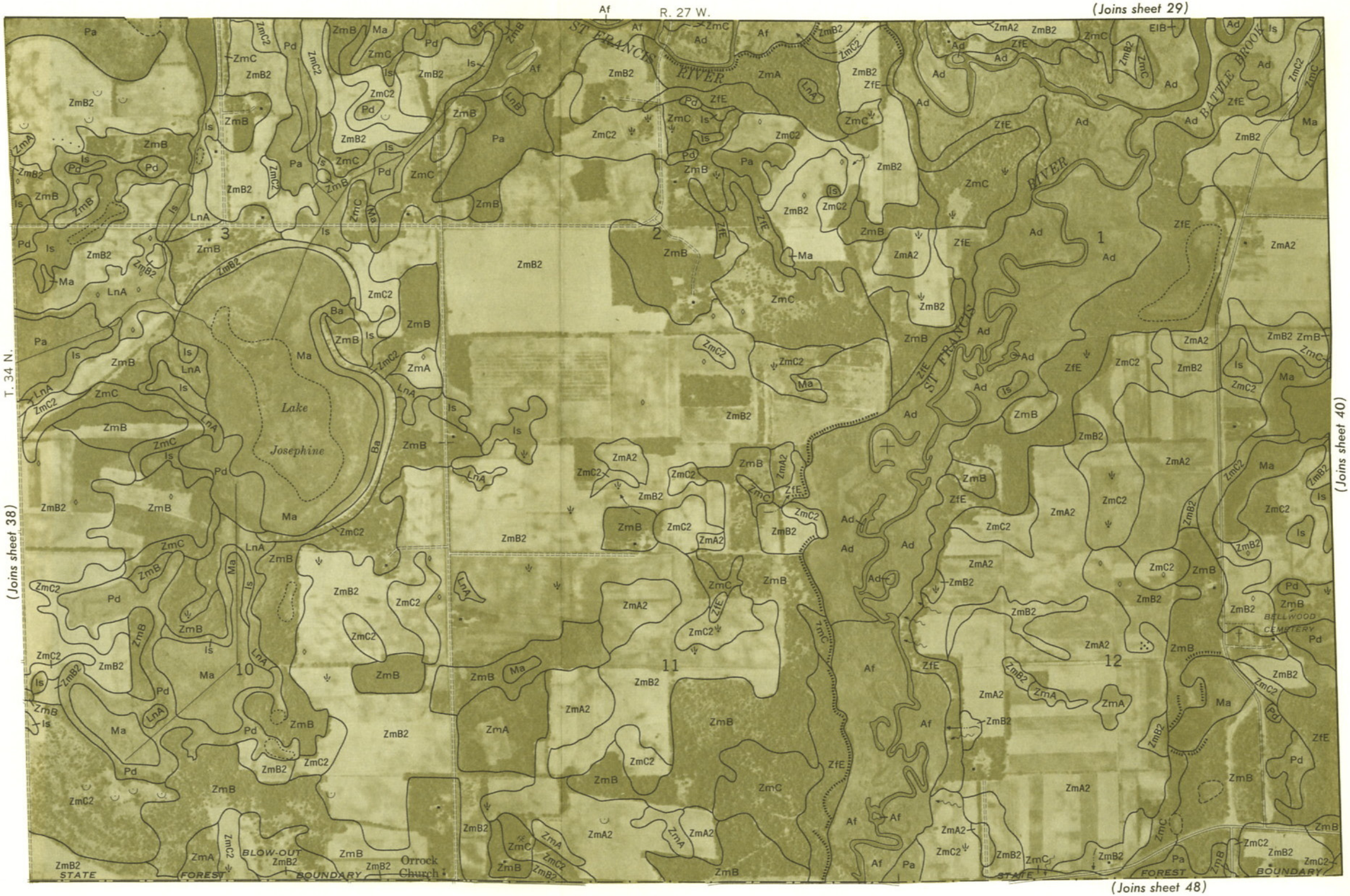

N
R. 29 W.
T. 34 N.
(Joins sheet 25)
(Joins sheet 34)
(Joins sheet 36)
(Joins sheet 44)
ELK LAKE
ELK RIVER
1
2
3
10
11
12


N
(Joins sheet 26)
R. 28 W.
T. 34 N.
(Joins sheet 35)
(Joins sheet 37)
(Joins sheet 45)
DANISH CEMETERY
GRAVEL PIT
6
5
4
8
9
25


R. 28 W.
(Joins sheet 27)
T. 34 N.
(Joins sheet 36)
(Joins sheet 38)
(Joins sheet 46)
N
Snake River
JOHNSON SLOUGH
BIG MUD LAKE
1
2
3
10
11
12

38


N
R. 27 W.
T. 34 N.
(Joins sheet 28)
(Joins sheet 37)
(Joins sheet 39)
(Joins sheet 47)
JOHNSON SLOUGH
BIG MUD LAKE
Orrock Church
Eidskog Church
Orrock
STATE FOREST BOUNDARY
6
5
4
7
8
9


R. 27 W.
T. 34 N.
(Joins sheet 29)
(Joins sheet 38)
(Joins sheet 40)
(Joins sheet 48)
N
ST FRANCIS RIVER
BATTLE BROOK
Lake Josephine
BELLWOOD CEMETERY
Orrock Church
BLOW-OUT
STATE FOREST BOUNDARY
1
2
3
10
11
12

(4)

N

BENTON COUNTY

R. 29 W.

T. 35 N.

(Joins sheet 3)

(Joins sheet 5)

(Joins sheet 14)

BEAN LAKE

RICE LAKE

Rice Cr.

HuA


N
(Joins sheet 30)
R. 26 W.
T. 34 N.
(Joins sheet 39)
(Joins sheet 41)
(Joins sheet 49)
LAKE
FREMONT
Lake Fremont
GREAT NORTHERN
5
6
7
8
9
4
ZmB
ZmB2
ZmC
ZmC2
ZmA
ZmA2
ZfE
Ma
Is
Pn
Pd
LnA
LnB
EIC
EIB
EmD
EmD2
EIC2
EIC3
EIB2
ChB2
ChC
Pa
Ba


N
R. 26 W.
T. 34 N.
(Joins sheet 31)
(Joins sheet 40)
(Joins sheet 50)
LAKE
FREMONT
ISANTI COUNTY
1
2
3
10
11
12

N

(Sh 32) | (Joins sheet 33)

(Joins lower right)

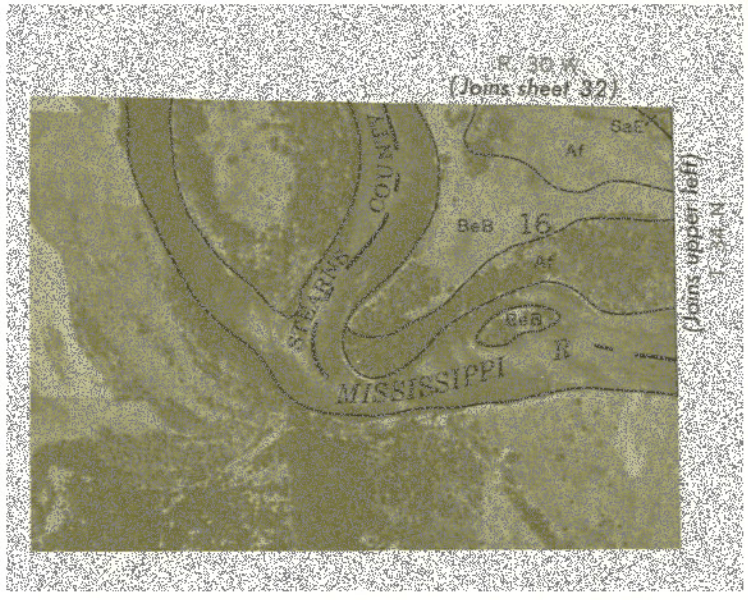
R. 30 W.

T. 34 N.

MISSISSIPPI RIVER

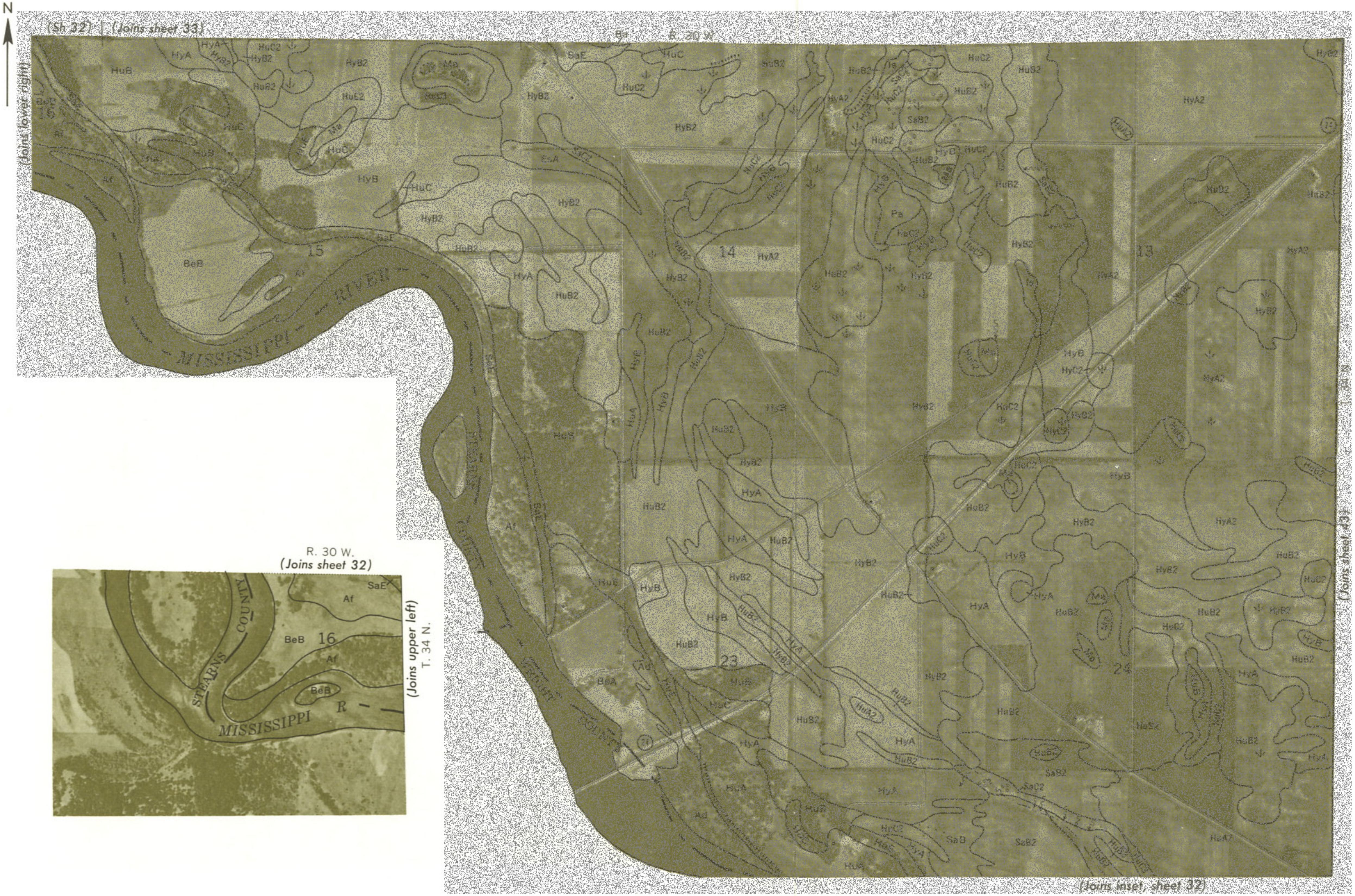
STEARNS COUNTY

WRIGHT COUNTY



(Joins inset, sheet 32)

(Joins sheet 43)


N
(Sh 32) | (Joins sheet 33)
R. 30 W.
(Joins lower right)
(Joins sheet 43)
(Joins inset, sheet 32)
MISSISSIPPI RIVER
WRIGHT COUNTY
15
14
13
23
24
HuB
HyA
HyB2
HuC2
HuB2
HyA2
HyB
BeB
Af
EsA
SaE
SaB2
HuC
R. 30 W.
(Joins sheet 32)
(Joins upper left)
T. 34 N.
STEARNS COUNTY
MISSISSIPPI R
16
BeB
Af
SaE

N

R. 29 W.

(Joins sheet 34)

T. 34 N.

Clear Lake

CAMP LAKE

MOSFORD LAKE

JONES LAKE

CRESCENT LAKE

GREAT NORTHERN

NORTHERN PACIFIC

18 17 16 19 20 21

(Joins sheet 42)

(Joins sheet 44)

(Joins sheet 51)

N

(Joins sheet 35)

R. 29 W.

(Joins sheet 43)

(Joins sheet 45)

T. 34 N.

(Joins sheet 52)

PRAIRIE LAKE

ELK RIVER

GREAT NORTHERN PACIFIC

Clitty Lake

15 14 13 22 23 24

N

R. 28 W.

(Joins sheet 36)

T. 34 N.

(Joins sheet 44)

(Joins sheet 46)

(Joins sheet 53)

RIVER

ELK

Clitty Lake

17

18

19

20

21

16

(46)

N

(Joins sheet 37)

R. 28 W.

T. 34 N.

(Joins sheet 45)

(Joins sheet 47)

(Joins sheet 54)

Snake River Church

Snake River

Danzel Slough

Duffy Lake

15

14

13

22

23

24

N

R. 27 W.

(Joins sheet 38)

T. 34 N.

(Joins sheet 46)

(Joins sheet 48)

(Joins sheet 55)

Orrock

SAND DUNES STATE FOREST

LAKE ANN

BLOWOUT

16 17 18 19 20 21

N

(Joins sheet 39)

R. 27 W.

T. 34 N.

(Joins sheet 47)

(Joins sheet 49)

(Joins sheet 56)

S A N D D U N E S

S T A T E F O R E S T

ANN LAKE

ST FRANCIS RIVER

BLOWOUT

15 14 13 22 23 24


N
R. 26 W.
(Joins sheet 40)
Lake Fremont
FREMONT WILDLIFE MANAGEMENT AREA
T. 34 N.
STATE FOREST BOUNDARY
GREAT NORTHERN
(Joins sheet 48)
(Joins sheet 50)
(Joins sheet 57)
16
17
18
19
20
21

SHERBURNE COUNTY, MINNESOTA — SHEET NUMBER 5

5

N

BENTON COUNTY

R. 29 W.

T. 35 N.

RICE LAKE

Stony Brook

Briggs Creek

(Joins sheet 4)

(Joins sheet 6)

(Joins sheet 15)

50

N

(Joins sheet 41)

R. 26 W.

T. 34 N.

ISANTI COUNTY

(Joins sheet 49)

(Joins sheet 58)

WEST HUNTER LAKE

EAST HUNTER LAKE

GRAVEL PIT

169

13 14 15 22 23 24


N
(Joins sheet 43)
R. 29 W.
T. 34 N.
(Joins inset, sheet 32)
(Joins sheet 52)
(Joins inset, sheet 59)
WRIGHT COUNTY
MISSISSIPPI RIVER
29
28
30
32
33
HuA2
HuA
HuB
HuB2
HuC
HuC2
HuC3
HuE
HuE2
HuB3
HyA
HyA2
HyB
SaB
SaB2
SaC
SaC2
SaE
Ma
Is
Pa
BeA
Af
Ad
ZmA2
LnA
PC

SHERBURNE COUNTY, MINNESOTA — SHEET NUMBER 52

52

N

(Joins sheet 44)

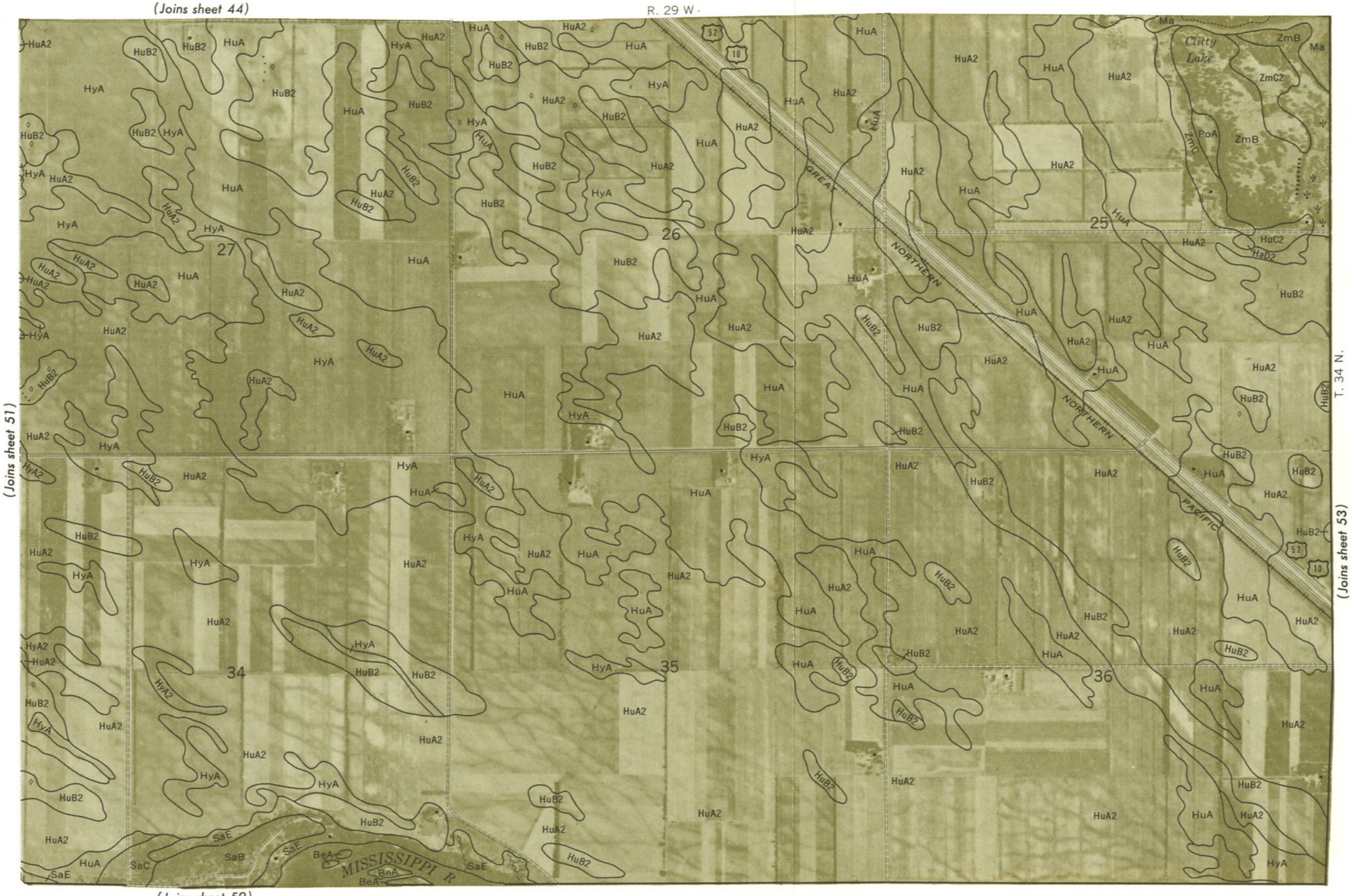
R. 29 W.

(Joins sheet 51)

(Joins sheet 53)

T. 34 N.

(Joins sheet 59)




N
R. 28 W.
(Joins sheet 45)
T. 34 N.
(Joins sheet 52)
(Joins sheet 54)
(Joins sheet 60)
Becker
BECKER CEMETERY
ELK RIVER
GRAVEL PIT
GRAVEL PIT
Becker Church
29
28
30
31
32
33
25
52
10
25
G N
N P

54

N

(Joins sheet 46)

R. 28 W.

T. 34 N.

(Joins sheet 53)

(Joins sheet 55)

(Joins sheet 61)

Duffy Lake

LUNDBERG SLOUGH

FREDERICKSON SLOUGH

Snake River

26

27

25

34

35

36

R. 27 W.

(Joins sheet 47)

N

T. 34 N.

(Joins sheet 54)

(Joins sheet 56)

(Joins sheet 62)

SAND DUNES STATE FOREST

EAGLE LAKE

Jensen Slough

ST FRANCIS RIVER

BLOWOUT

BLOWOUT

S. D.

29 30 28 31 32 33

ZmC ZmC2 ZmB ZmB2 ZmA2 ZmA Pd Is Ma ZfE LnB LnA Lw Pa HaD3 HaC3 HaB2 LsA HaB HaE HaC HyB HaD HyC2 HuE2 HuC HuB HuE2 HuE HuA2 Ba SaE Ad Af

N

(Joins sheet 48)

R. 27 W.

(Joins sheet 55)

(Joins sheet 57)

T. 34 N.

(Joins sheet 63)

RIVER

Larsen Slough

S A N D D U N E S

S T A T E F O R E S T

ST FRANCIS BLOW OUT

SVEA HILL CEMETERY

Svea Hill Church

27 26 25 34 35 36


N
(Joins sheet 49)
R. 26 W.
T. 34 N.
(Joins sheet 56)
(Joins sheet 58)
(Joins sheet 64)
STATE FOREST BOUNDARY
Lake of the Woods
30
29
28
31
32
33
Tibbits Brook
GREAT NORTHERN
RICE LAKE
MEADOWVILLE CEMETERY

N

(Joins sheet 50)

R. 26 W.

ANOKA COUNTY

T. 34 N.

(Joins sheet 57)

(Joins sheet 65)

(Joins lower right)

R. 29 W.

(Joins sheet 52)

N

HuA SaC SaE SaB BeA

WRIGHT COUNTY

SaE HuB2 HuA2 HuB2 HyA

Af

MISSISSIPPI RIVER

HuB2 HuA2 HuB2 HuA HuB2 HuA2

HuB HuB2 HuA2 HuA2 HuA2

SaE EsA SaC2 HyA HuA2 HuA HuB2

HuA2 HuB2 HuB2

BeA EsA HyA HuA

SaE HuC2 HuB2 HuA2

SaB EsA HuA

SaE BeA SaE HuB2 HyA HuA HuA2

WRIGHT COUNTY

SaB HuA2

SaE HuB2

T. 33 N.

(Joins sheet 60)

(Joins sheet 66)

R. 29 W.

(Joins sheet 51)

HyA HuB2 HuE

BeA

Af

SaE

WRIGHT COUNTY

MISSISSIPPI RIVER

BeA

(Joins upper left)


R. 29 W.
(Joins sheet 52)
(Joins lower right)
WRIGHT COUNTY
MISSISSIPPI RIVER
HuA2
HuB2
HuE2
HuA
HyA
EsA
SaE
SaB
BeA
BeB
Af
1
2
3
4
5
N
(Joins sheet 60)
(Joins sheet 66)
R. 29 W.
(Joins sheet 51)
(Joins upper left)

SHERBURNE COUNTY, MINNESOTA — SHEET NUMBER 6

6

N

BENTON COUNTY

R. 28 W.

T. 35 N.

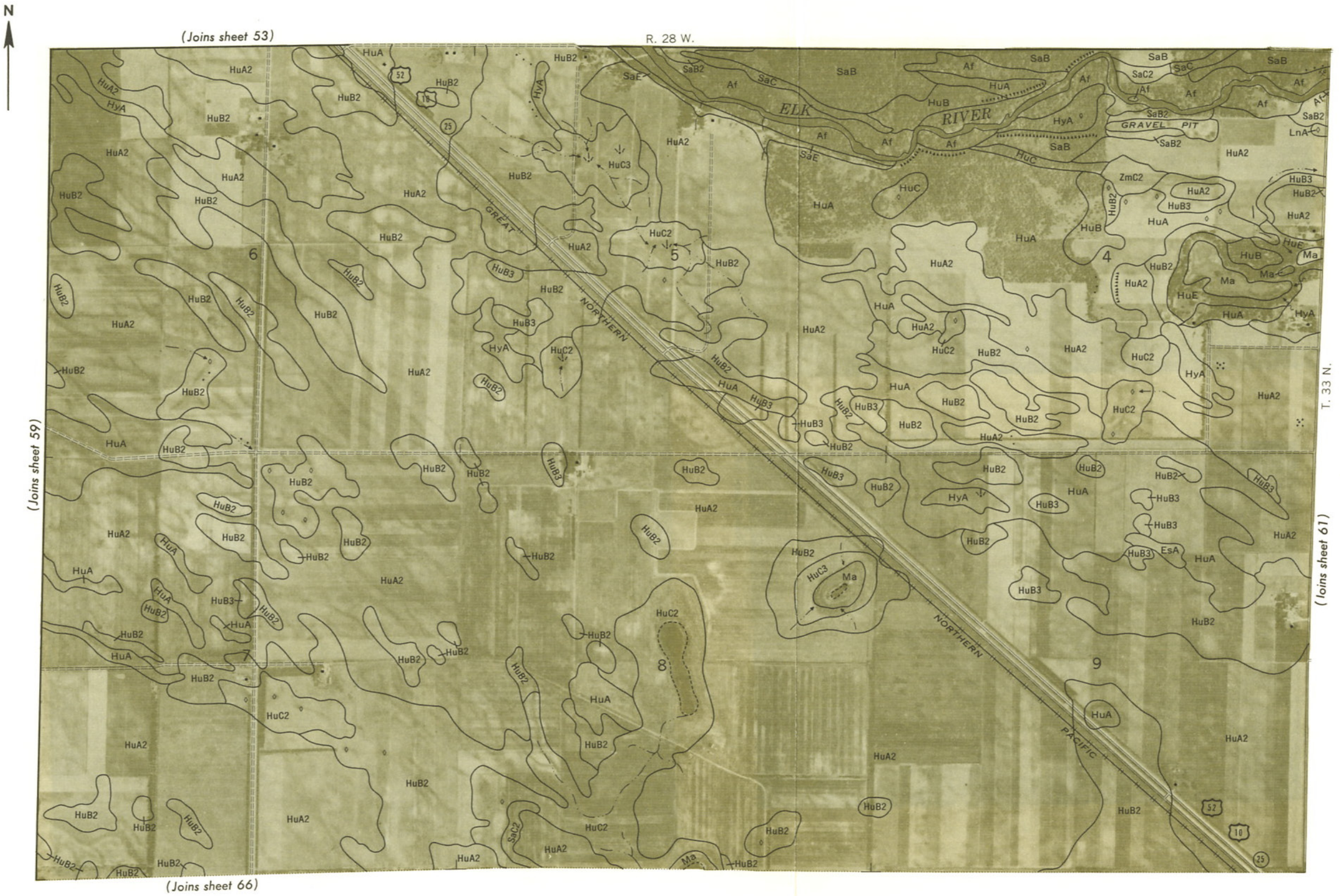
(Joins sheet 5)

(Joins sheet 7)

(Joins sheet 16)

Santiago

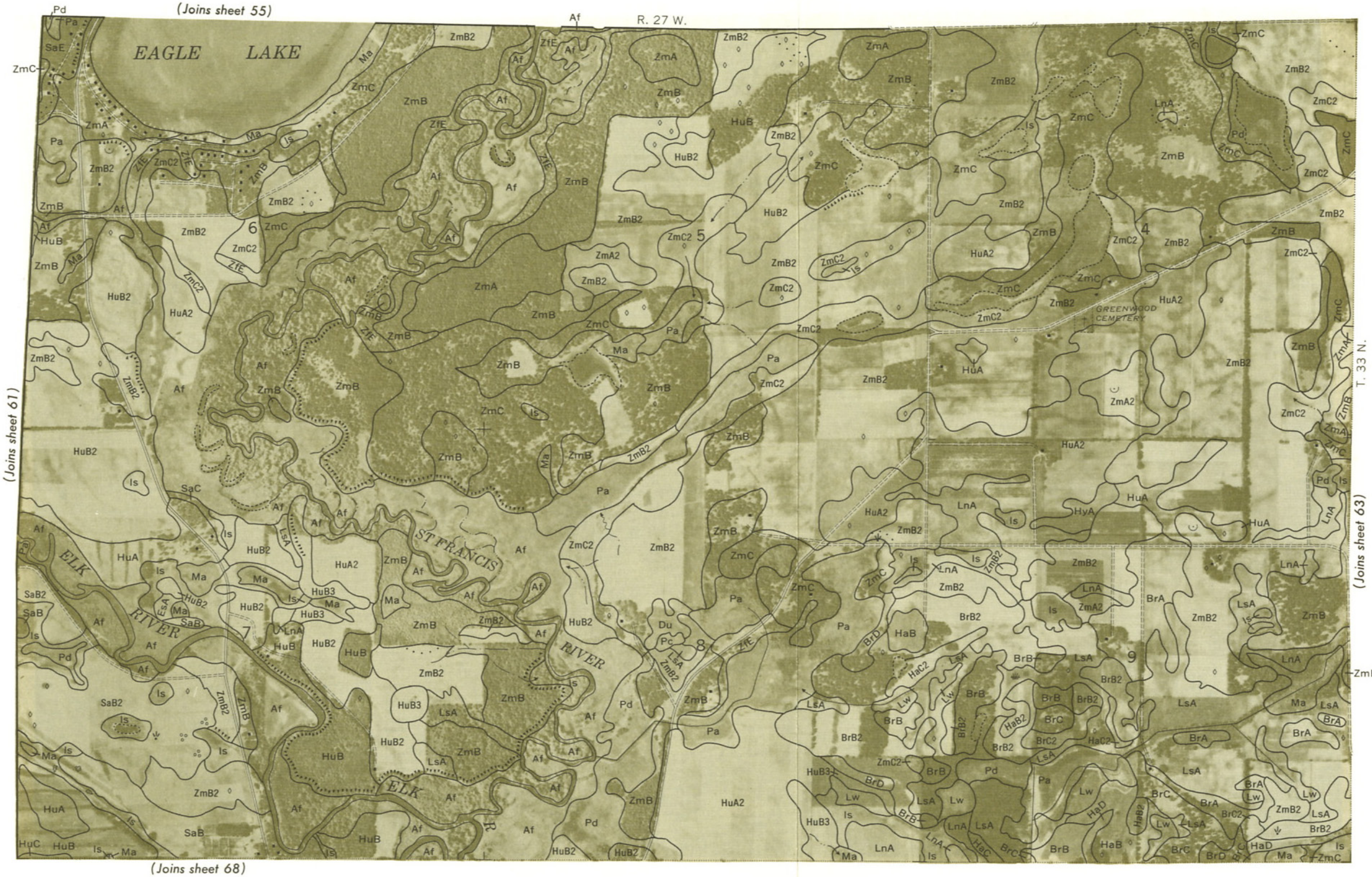
St. Francis River


N
(Joins sheet 53)
R. 28 W.
T. 33 N.
(Joins sheet 59)
(Joins sheet 61)
(Joins sheet 66)
ELK RIVER
GREAT NORTHERN
NORTHERN PACIFIC
GRAVEL PIT
HuA
HuA2
HuB2
HuB3
HuC2
HuC3
HuC
HuB
HyA
SaB
SaB2
SaC
SaC2
SaE
Af
ZmC2
HuE
Ma
EsA
LnA
1
2
3
4
5
6
7
8
9
52
10
25


R. 28 W.
T. 33 N.
N
(Joins sheet 54)
(Joins sheet 60)
(Joins sheet 62)
(Joins sheet 67)
ELK RIVER
BUCKS LAKE
HIDDEN LAKE
STRAND LAKE
THOMPSON LAKE
Snake River
1
2
3
10
11
12

62

N


(Joins sheet 55)
R. 27 W.
T. 33 N.
EAGLE LAKE
ELK RIVER
ST FRANCIS RIVER
ELK R
GREENWOOD CEMETERY
(Joins sheet 61)
(Joins sheet 63)
(Joins sheet 68)
ZmB
ZmB2
ZmC
ZmC2
ZmA
ZmA2
Af
Ma
Pa
Pd
Is
HuB
HuB2
HuA
HuA2
HuB3
SaB
SaB2
SaC
SaE
ZfE
LsA
LnA
HyA
BrA
BrB
BrB2
BrC
BrC2
BrD
HaB
HaC
HaD
HaB2
HaC2
Lw
Du
Pc
HuC
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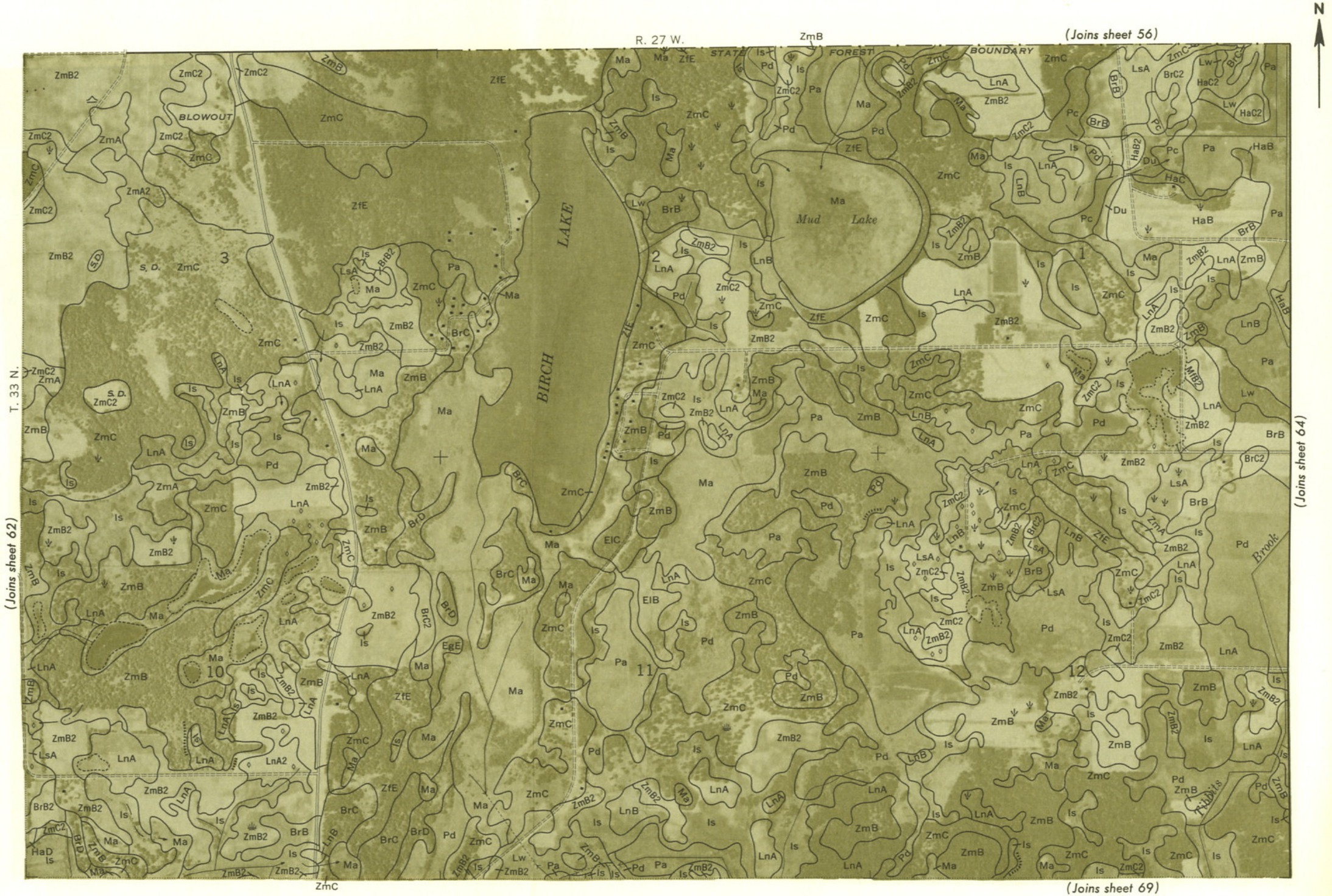
9


R. 27 W.
(Joins sheet 56)
N
T. 33 N.
(Joins sheet 62)
(Joins sheet 64)
(Joins sheet 69)
BIRCH LAKE
Mud Lake
STATE FOREST BOUNDARY
BLOWOUT
Brook
1
2
3
10
11
12

64

N

(Joins sheet 57)

R. 26 W.

(Joins sheet 63)

(Joins sheet 65)

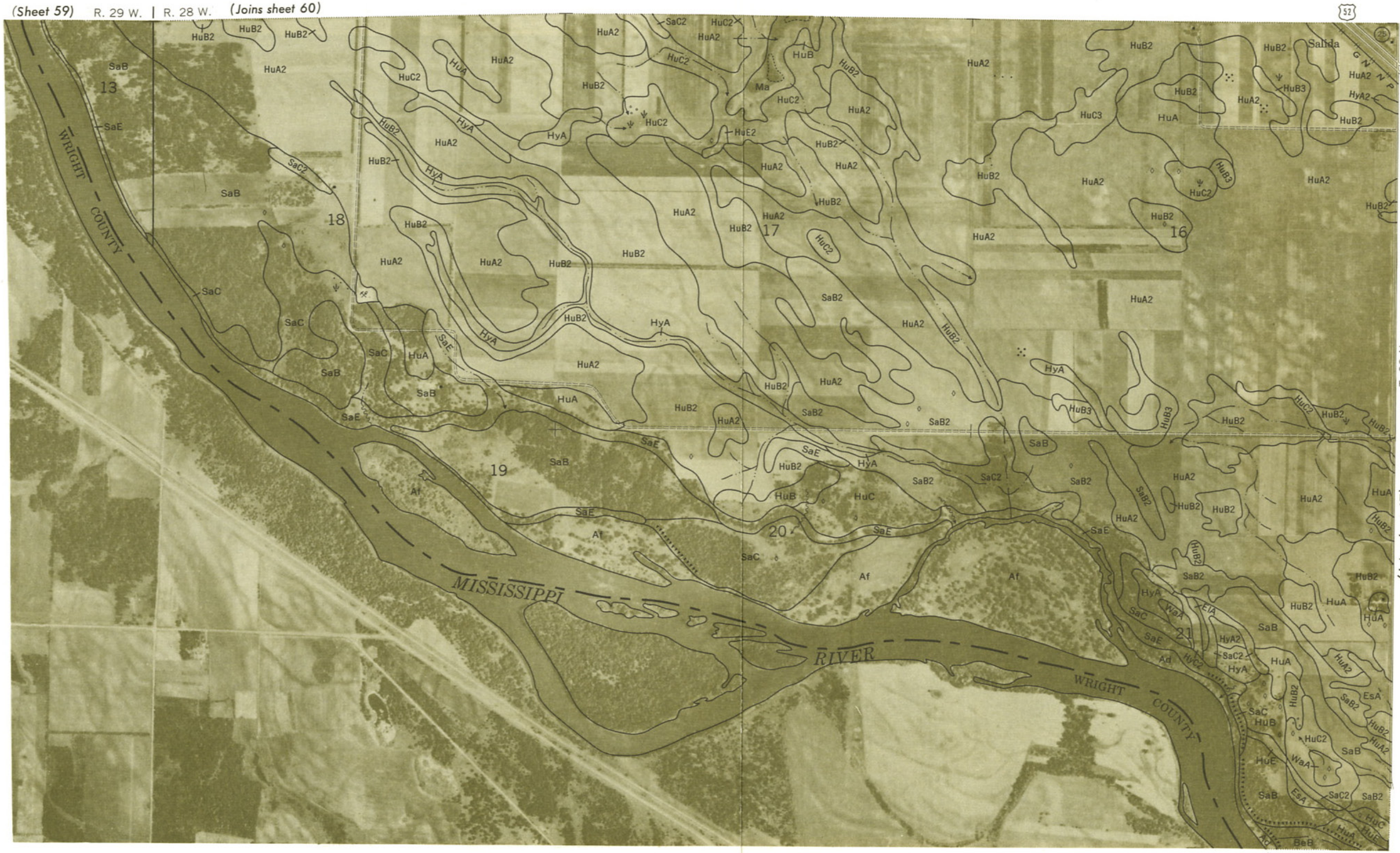
T. 33 N.

(Joins sheet 70)


N
R. 26 W.
(Joins sheet 58)
T. 33 N.
(Joins sheet 64)
ANOKA COUNTY
(Joins sheet 71)
GRAVEL PIT
169

N

(Sheet 59) R. 29 W. | R. 28 W. (Joins sheet 60)



(Joins sheet 67)

(Joins sheet 72)

N

R. 28 W.

(Joins sheet 61)

T. 33 N.

(Joins sheet 66)

(Joins sheet 68)

(Joins sheet 72)

THOMPSON LAKE

WOOD LAKE

Landis Lake

MITCHELL LAKE

BLACKS LAKE

BIG LAKE

Keller Lake

Beulah Pond

GREAT NORTHERN

NORTHERN PACIFIC

15 14 13 22 23 24

N

(Joins sheet 62)

R. 27 W.

T. 33 N.

(Joins sheet 67)

(Joins sheet 69)

(Joins sheet 73)

LAKE MITCHELL

BIG LAKE

Big Lake

Keller Lake

Lake Preusse

ELK RIVER

GREAT NORTHERN

NORTHERN PACIFIC

DUMP

B. P.

18

17

16

19

20

21


R. 27 W.
T. 33 N.
N
(Joins sheet 63)
(Joins sheet 68)
(Joins sheet 70)
(Joins sheet 74)
ELK RIVER
ELK RIVER
Tributary
Brook
13
14
15
22
23
24

SHERBURNE COUNTY, MINNESOTA — SHEET NUMBER 7

7

N

R. 28 W.

BENTON COUNTY

T. 35 N.

(Joins sheet 6)

(Joins sheet 8)

(Joins sheet 17)

Santiago

St. Francis River

10

11

12

1

2

3

70

N

(Joins sheet 64)

R. 26 W.

T. 33 N.

(Joins sheet 69)

(Joins sheet 71)

(Joins sheet 75)

18 17 16 19 20 21

NORTHERN

GREAT

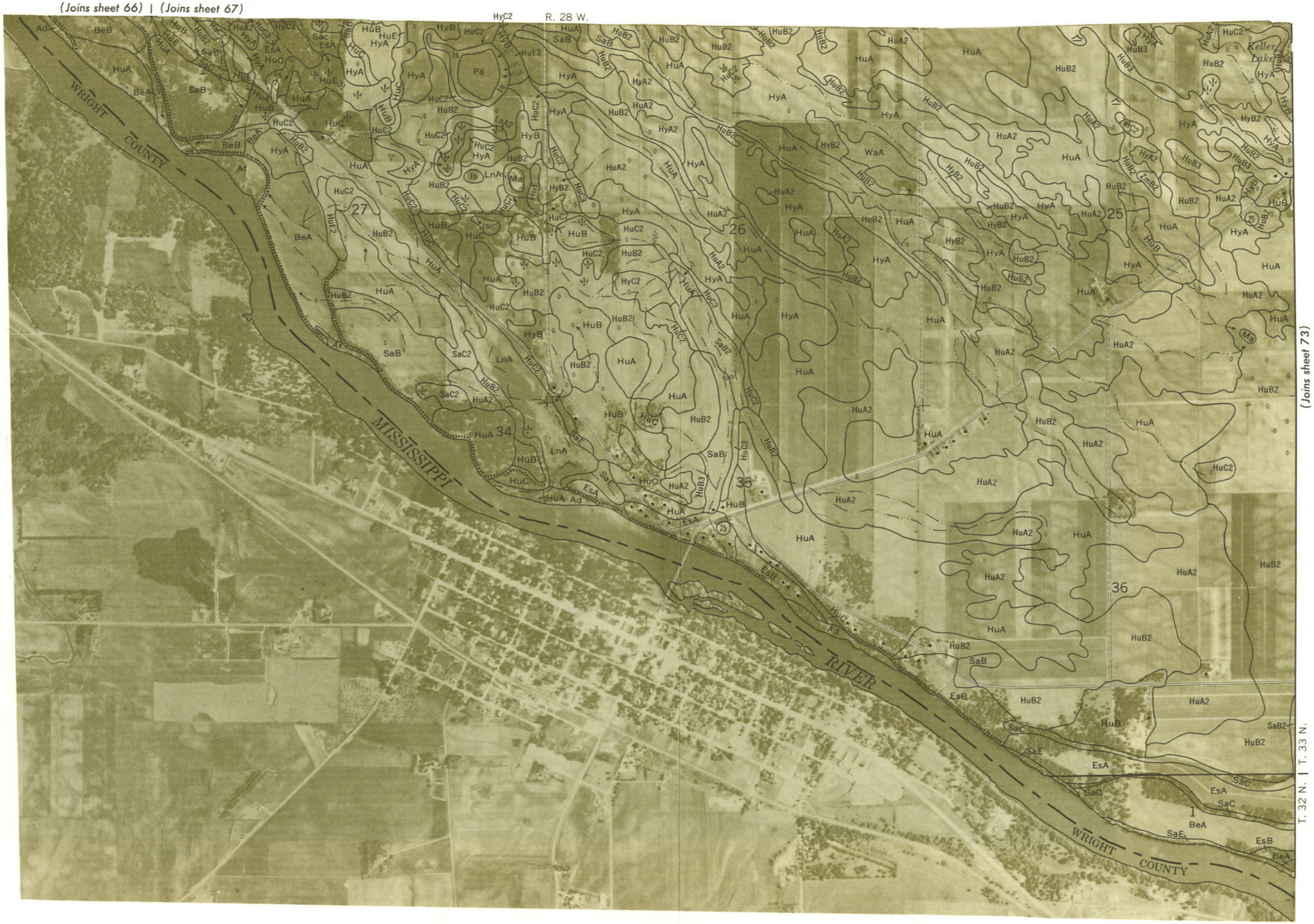
ELK RIVER COUNTRY CLUB


R. 26 W.
(Joins sheet 65)
T. 33 N.
(Joins sheet 70)
ANOKA COUNTY
N
EAGLE LAKE
Little Twin Lake
WEST TWIN LAKE
GRAVEL PIT
Pratt
Bryant
15
14
13
22
23
24
(Joins sheet 76)

(Joins sheet 66) | (Joins sheet 67)

N

R. 28 W.



(Joins sheet 73)

T. 32 N. | T. 33 N.

R. 27 W.

(Joins sheet 68)

(Joins sheet 72)

(Joins sheet 74)

T. 32 N. | T. 33 N.

Keller Lake

Big Lake

GREAT NORTHERN

NORTHERN PACIFIC

MISSISSIPPI RIVER

WRIGHT COUNTY

30 29 28 31 32 33 6 4

HuC2 HuB HuA HuA2 HuB2 HyB HyA HyB2 LnA Is Du HuC Ma Pd SaB2 SaC2 SaC SaE EsA EsB BeA Ad EgE EgC Sac At

74

N

R. 27 W.

(Joins sheet 69)

(Joins sheet 73)

(Joins sheet 75)

T. 32 N. | T. 33 N.

GREAT NORTHERN PACIFIC

BORROW PIT

ELK RIVER

MISSISSIPPI RIVER

WRIGHT COUNTY

Bailey

27 26 25

34 35 36

2 1

R. 26 W.

(Joins sheet 70)

N

(Joins sheet 74)

(Joins sheet 77) | (Joins sheet 76)

T. 32 N. | T. 33 N.

GREAT NORTHERN

NORTHERN PACIFIC

RIVER

ELK

ORONO LAKE

ORONO CEM

ELK RIVER (COUNTY SEAT)

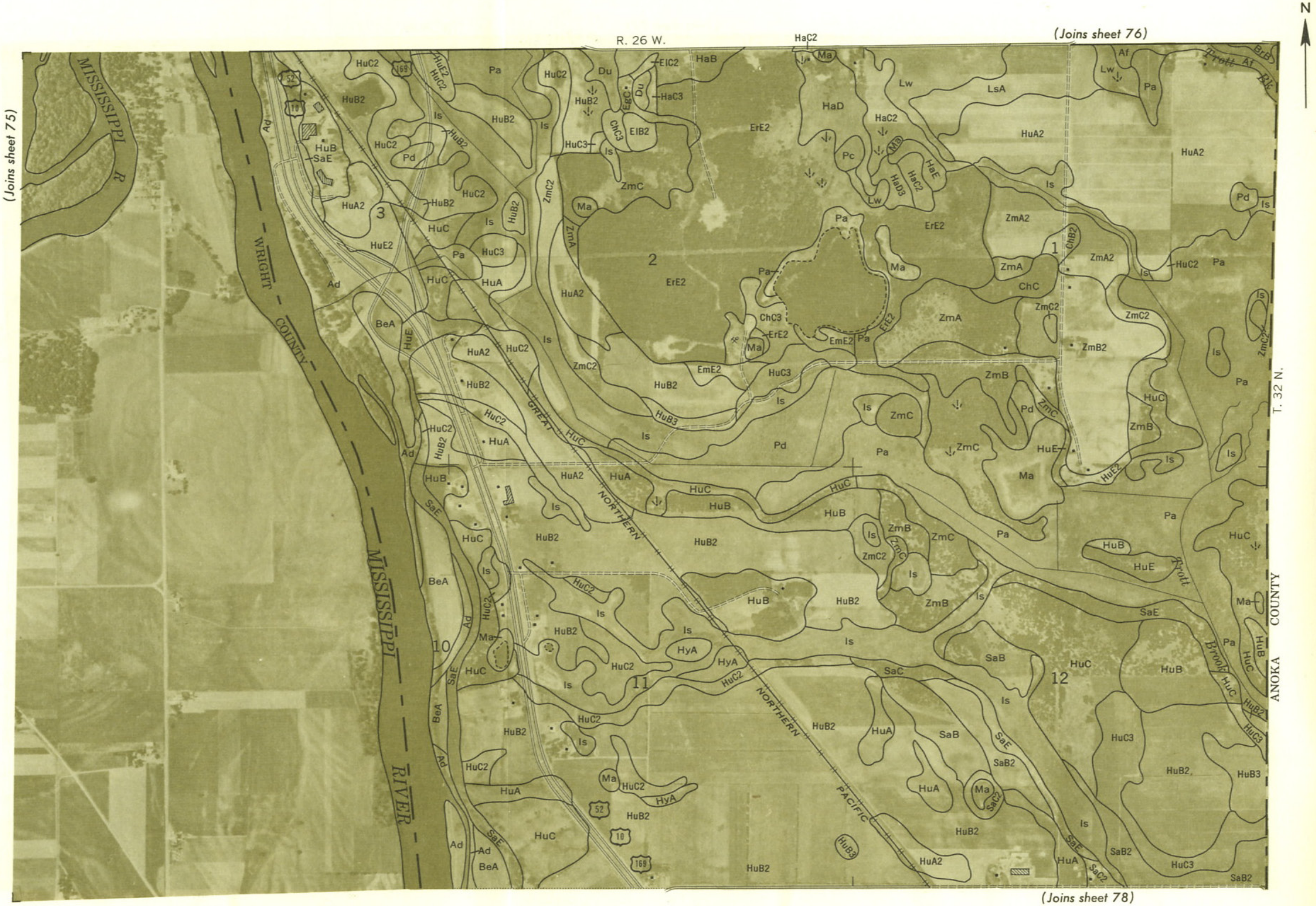
GRAVEL PIT

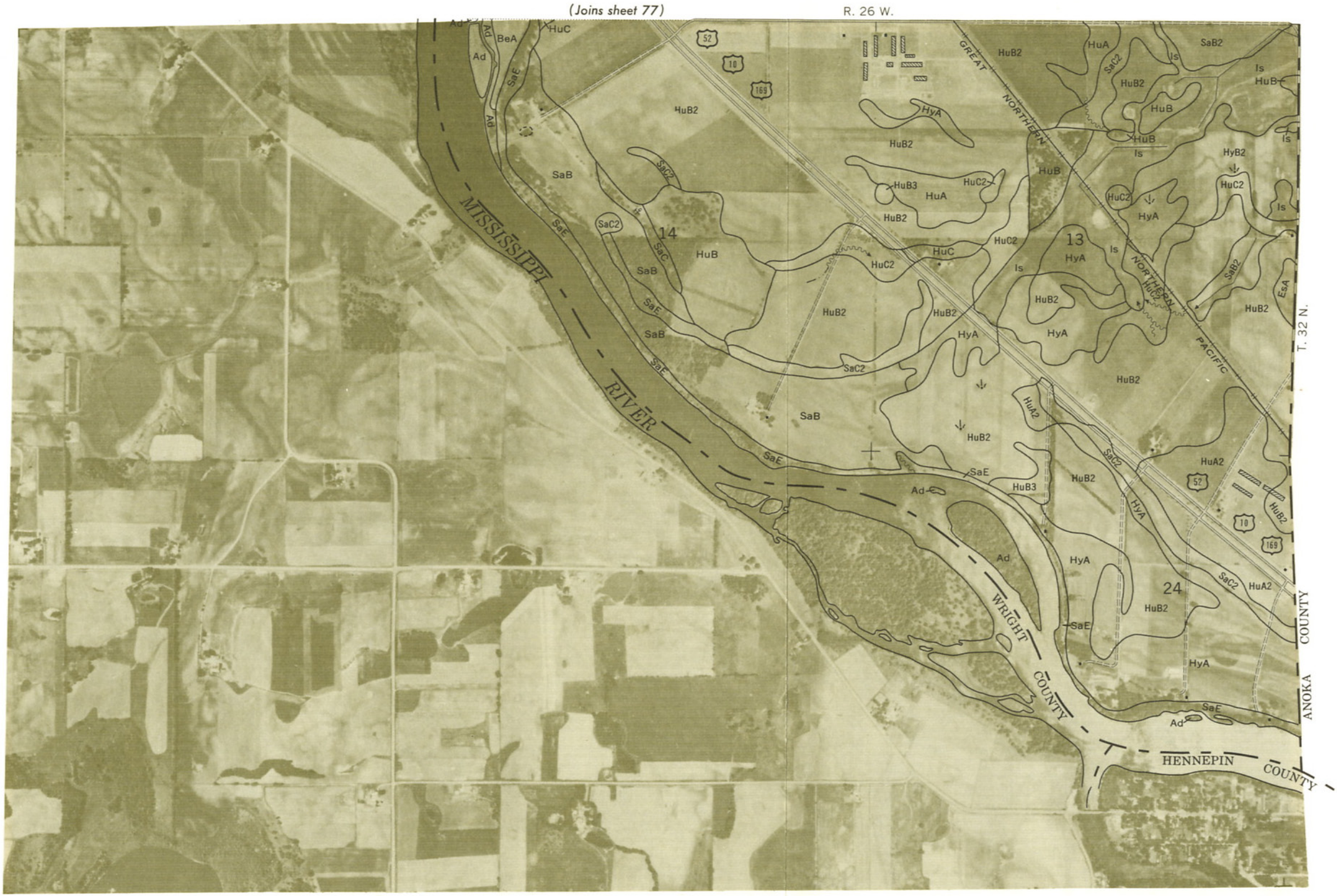
WRIGHT COUNTY

MISSISSIPPI RIVER

30 29 28 31 32 33 6 5 4


N
(Joins sheet 71)
R. 26 W.
(Joins sheet 75)
T. 33 N.
ANOKA COUNTY
(Joins sheet 77)
ELK RIVER
(COUNTY SEAT)
ST ANDREWS CEMETERY
MISSISSIPPI
WRIGHT
RIVER
COUNTY
Trott Brook
G N
N P
27
26
25
34
35
36


N
R. 26 W.
(Joins sheet 76)
(Joins sheet 75)
(Joins sheet 78)
T. 32 N.
ANOKA COUNTY
WRIGHT COUNTY
MISSISSIPPI R
MISSISSIPPI RIVER
GREAT NORTHERN
NORTHERN PACIFIC
Trott Brook
1
2
3
10
11
12
ErE2
HuB2
HuC2
HuA2
ZmA
ZmC
ZmB
Pa
Pd
Is
Ma
SaE
SaB
SaC
BeA
Ad
HuC
HuB
HuA
HyA
HaD
LsA
Lw
ChC
HuC3
HuB3
SaB2


N
(Joins sheet 77)
R. 26 W.
T. 32 N.
MISSISSIPPI RIVER
GREAT NORTHERN
NORTHERN PACIFIC
WRIGHT COUNTY
ANOKA COUNTY
HENNEPIN COUNTY
14
13
24
HuC
BeA
Ad
SaE
HuB2
SaB
SaC2
HuB
HyA
HuB3
HuA
HuC2
HuA2
HyB2
Is
SaB2
ESA
52
10
169

SHERBURNE COUNTY, MINNESOTA — SHEET NUMBER 8

8

N

MILLE LACS COUNTY

R. 27 W.

T. 35 N.

(Joins sheet 7)

(Joins sheet 9)

(Joins sheet 18)

MILLE LACS COUNTY

R. 27 W.

N

T. 35 N.

(Joins sheet 8)

(Joins sheet 10)

(Joins sheet 19)

ST. FRANCIS RIVER

Battle Brook

1 2 3 10 11 12

GUIDE TO MAPPING UNITS

[For a full description of a mapping unit, read both the description of the mapping unit and the description of the soils series to which the mapping unit belongs.

[See table 1, p. 8, for approximate acreage and proportionate extent of the soils and table 2, p. 42, for estimated yields per acre of the principal crops. For facts about the engineering properties of the soils, turn to the section beginning on p. 51]

Map symbol	Mapping unit	Described on page	Capability unit		Woodland group	
			Symbol	Page	Number	Page
Ad	Alluvial land	9	IIw-2	30	9	49
Af	Alluvial land, frequently flooded	9	VIw-1	39	9	49
Ap	Adolph loam	7	IIIw-1	32	8	49
Ba	Beach sand	10	VIs-3	40	1	46
BeA	Becker loam, 0 to 2 percent slopes	10	IIs-1	30	4	48
BeB	Becker loam, 2 to 6 percent slopes	10	IIs-1	30	4	48
BrA	Braham loamy fine sand, 0 to 2 percent slopes	10	IIIs-2	34	5	48
BrB	Braham loamy fine sand, 2 to 6 percent slopes	10	IIIs-2	34	5	48
BrB2	Braham loamy fine sand, 2 to 6 percent slopes, eroded	10	IIIs-2	34	5	48
BrC	Braham loamy fine sand, 6 to 12 percent slopes	11	IVs-2	37	5	48
BrC2	Braham loamy fine sand, 6 to 12 percent slopes, eroded	11	IVs-2	37	5	48
BrD	Braham loamy fine sand, 12 to 18 percent slopes	11	VIs-2	39	5	48
BuA	Burkhardt sandy loam, 0 to 2 percent slopes	11	IIIs-1	33	2	47
BuB	Burkhardt sandy loam, 2 to 6 percent slopes	11	IIIe-2	31	2	47
BuB2	Burkhardt sandy loam, 2 to 6 percent slopes, eroded	11	IIIe-2	31	2	47
ChA	Chetek sandy loam, 0 to 2 percent slopes	12	IIIs-1	33	2	47
ChB	Chetek sandy loam, 2 to 6 percent slopes	12	IIIe-2	31	2	47
ChB2	Chetek sandy loam, 2 to 6 percent slopes, eroded	12	IIIe-2	31	2	47
ChC	Chetek sandy loam, 6 to 12 percent slopes	12	IVe-2	35	2	47
ChC2	Chetek sandy loam, 6 to 12 percent slopes, eroded	12	IVe-2	35	2	47
ChC3	Chetek sandy loam, 6 to 12 percent slopes, severely eroded	12	VIe-2	38	2	47
Du	Dundas loam	13	IIw-1	30	8	49
EgC	Emmert gravelly loamy sand, 6 to 12 percent slopes	13	VIs-1	39	3	47
EgE	Emmert gravelly loamy sand, 12 to 35 percent slopes	13	VIIs-1	40	3	47
ElA	Emmert loamy sand, 0 to 2 percent slopes	13	IVs-1	36	3	47
ElB	Emmert loamy sand, 2 to 6 percent slopes	13	IVs-1	36	3	47
ElB2	Emmert loamy sand, 2 to 6 percent slopes, eroded	13	IVs-1	36	3	47
ElC	Emmert loamy sand, 6 to 12 percent slopes	14	IVs-1	36	3	47
ElC2	Emmert loamy sand, 6 to 12 percent slopes, eroded	14	IVs-1	36	3	47
ElC3	Emmert loamy sand, 6 to 12 percent slopes, severely eroded	14	VIs-1	39	3	47
EmD	Emmert and Chetek soils, 12 to 18 percent slopes	14	VIs-1	39	3	47
EmD2	Emmert and Chetek soils, 12 to 18 percent slopes, eroded	14	VIs-1	39	3	47
EmE	Emmert and Chetek soils, 18 to 25 percent slopes	14	VIIs-1	40	3	47
EmE2	Emmert and Chetek soils, 18 to 25 percent slopes, eroded	14	VIIs-1	40	3	47
ErB2	Emmert-Hayden complex, 2 to 6 percent slopes, eroded	15	IIIe-2	31	2	47
ErC2	Emmert-Hayden complex, 6 to 12 percent slopes, eroded	15	IVe-2	35	2	47
ErD2	Emmert-Hayden complex, 12 to 18 percent slopes, eroded	15	VIe-2	38	3	47
ErE2	Emmert-Hayden complex, 18 to 25 percent slopes, eroded	15	VIIs-1	40	3	47
EsA	Estherville sandy loam, 0 to 2 percent slopes	15	IIIs-1	33	2	47
EsA2	Estherville sandy loam, 0 to 2 percent slopes, wind eroded	15	IIIs-1	33	2	47
EsB	Estherville sandy loam, 2 to 6 percent slopes	16	IIIe-2	31	2	47
EsB2	Estherville sandy loam, 2 to 6 percent slopes, eroded	16	IIIe-2	31	2	47
EsC	Estherville sandy loam, 6 to 12 percent slopes	16	IVe-2	35	2	47
EsC2	Estherville sandy loam, 6 to 12 percent slopes, eroded	16	IVe-2	35	2	47
FaA	Fairhaven silt loam, light-colored variant, 0 to 2 percent slopes	17	IIs-1	30	4	48
FaB	Fairhaven silt loam, light-colored variant, 2 to 6 percent slopes	17	IIs-1	30	4	48
HaA	Hayden fine sandy loam, 0 to 2 percent slopes	17	IIe-1	29	6	48
HaB	Hayden fine sandy loam, 2 to 6 percent slopes	17	IIe-1	29	6	48
HaB2	Hayden fine sandy loam, 2 to 6 percent slopes, moderately eroded	17	IIe-1	29	6	48
HaC	Hayden fine sandy loam, 6 to 12 percent slopes	18	IIIe-1	31	6	48
HaC2	Hayden fine sandy loam, 6 to 12 percent slopes, moderately eroded	18	IIIe-1	31	6	48
HaC3	Hayden fine sandy loam, 6 to 12 percent slopes, severely eroded	18	IVe-1	34	6	48
HaD	Hayden fine sandy loam, 12 to 18 percent slopes	18	IVe-1	34	7	49
HaD2	Hayden fine sandy loam, 12 to 18 percent slopes, moderately eroded	18	IVe-1	34	7	49
HaD3	Hayden fine sandy loam, 12 to 18 percent slopes, severely eroded	18	VIe-1	38	7	49
HaE	Hayden fine sandy loam, 18 to 35 percent slopes	18	VIe-1	38	7	49
HuA	Hubbard loamy sand, 0 to 2 percent slopes	19	IVs-3	37	1	46
HuA2	Hubbard loamy sand, 0 to 2 percent slopes, wind eroded	19	IVs-3	37	1	46
HuB	Hubbard loamy sand, 2 to 6 percent slopes	19	IVs-3	37	1	46
HuB2	Hubbard loamy sand, 2 to 6 percent slopes, eroded	19	IVs-3	37	1	46
HuB3	Hubbard loamy sand, 2 to 6 percent slopes, severely eroded	20	VIs-3	40	1	46
HuC	Hubbard loamy sand, 6 to 12 percent slopes	20	VIs-3	40	1	46
HuC2	Hubbard loamy sand, 6 to 12 percent slopes, eroded	20	VIs-3	40	1	46
HuC3	Hubbard loamy sand, 6 to 12 percent slopes, severely eroded	20	VIIs-1	40	1	46
HuE	Hubbard loamy sand, 12 to 25 percent slopes	20	VIIs-1	40	1	46
HuE2	Hubbard loamy sand, 12 to 25 percent slopes, eroded	20	VIIs-1	40	1	46
HyA	Hubbard sandy loam, 0 to 2 percent slopes	20	IIIs-1	33	1	46
HyA2	Hubbard sandy loam, 0 to 2 percent slopes, wind eroded	21	IIIs-1	33	1	46
HyB	Hubbard sandy loam, 2 to 6 percent slopes	21	IIIe-2	31	1	46
HyB2	Hubbard sandy loam, 2 to 6 percent slopes, eroded	21	IIIe-2	31	1	46
HyC2	Hubbard sandy loam, 6 to 12 percent slopes, eroded	21	IVe-2	35	1	46
Is	Isanti loamy fine sand	21	IVw-2	35	11	50
LnA	Lino loamy fine snnd, 0 to 2 percent slopes	22	IIIw-2	32	9	49
LnA2	Lino loamy fine sand, 0 to 2 percent slopes, wind eroded	22	IIIw-2	32	9	49
LnB	Lino loamy fine sand, 2 to 6 percent slopes	22	IIIw-2	32	9	49
LsA	Lino loamy fine sand, loamy substratum, 0 to 2 percent slopes	22	IIIw-2	32	9	49
Lw	Loamy wet land	22	IVw-1	35	11	50
Ma	Marsh	22	VIIIw-1	40	11	50
MfA	Milaca fine sandy loam, 0 to 2 percent slopes	23	IIe-1	29	6	48
MfB	Milaca fine sandy loam, 2 to 6 percent slopes	23	IIe-1	29	6	48
MfB2	Milaca fine sandy loam, 2 to 6 percent slopes, moderately eroded	23	IIe-1	29	6	48
MfC2	Milaca fine sandy loam, 6 to 12 percent slopes, eroded	23	IIIe-1	31	6	48
MfD	Milaca fine sandy loam, 12 to 18 percent slopes	23	IVe-1	34	7	49
MfE	Milaca fine sandy loam, 18 to 25 percent slopes	23	VIe-1	38	7	49
MoA	Mora loam, 0 to 2 percent slopes	24	IIe-1	29	6	48
MoB	Mora loam, 2 to 6 percent slopes	24	IIe-1	29	6	48
Pa	Peat and muck, deep	24	IIIw-3	33	10	50
Pc	Peat and muck, shallow, over loam	24	IIIw-3	33	10	50
Pd	Peat and muck, shallow, over sand	24	IVw-3	36	10	50
Pn	Peat-Lino complex	24	IVw-2	35	11	50
PoA	Pomroy loamy fine sand, 0 to 2 percent slopes	25	IIIs-2	34	5	48
PoB	Pomroy loamy fine sand, 2 to 6 percent slopes	25	IIIs-2	34	5	48
Ro	Ronneby loam	25	IIw-1	30	8	49
SaB	Salida complex, 0 to 6 percent slopes	26	IVs-1	36	3	47
SaB2	Salida complex, 0 to 6 percent slopes, eroded	26	IVs-1	36	3	47
SaC	Salida complex, 6 to 12 percent slopes	26	IVs-1	36	3	47
SaC2	Salida complex, 6 to 12 percent slopes, eroded	26	IVs-1	36	3	47
SaE	Salida complex, 12 to 25 percent slopes	26	VIIs-1	40	3	47
WaA	Wadena loam, 0 to 2 percent slopes	27	IIs-1	30	4	48
ZfE	Zimmerman fine sand, 12 to 25 percent slopes	28	VIIs-1	40	1	46
ZmA	Zimmerman loamy fine sand, 0 to 2 percent slopes	27	IVs-3	37	1	46
ZmA2	Zimmerman loamy fine sand, 0 to 2 percent slopes, wind eroded	27	IVs-3	37	1	46
ZmB	Zimmerman loamy fine sand, 2 to 6 percent slopes	28	IVs-3	37	1	46
ZmB2	Zimmerman loamy fine sand, 2 to 6 percent slopes, eroded	28	IVs-3	37	1	46
ZmC	Zimmerman loamy fine sand, 6 to 12 percent slopes	28	VIs-3	40	1	46
ZmC2	Zimmerman loamy fine sand, 6 to 12 percent slopes, eroded	28	VIs-3	40	1	46